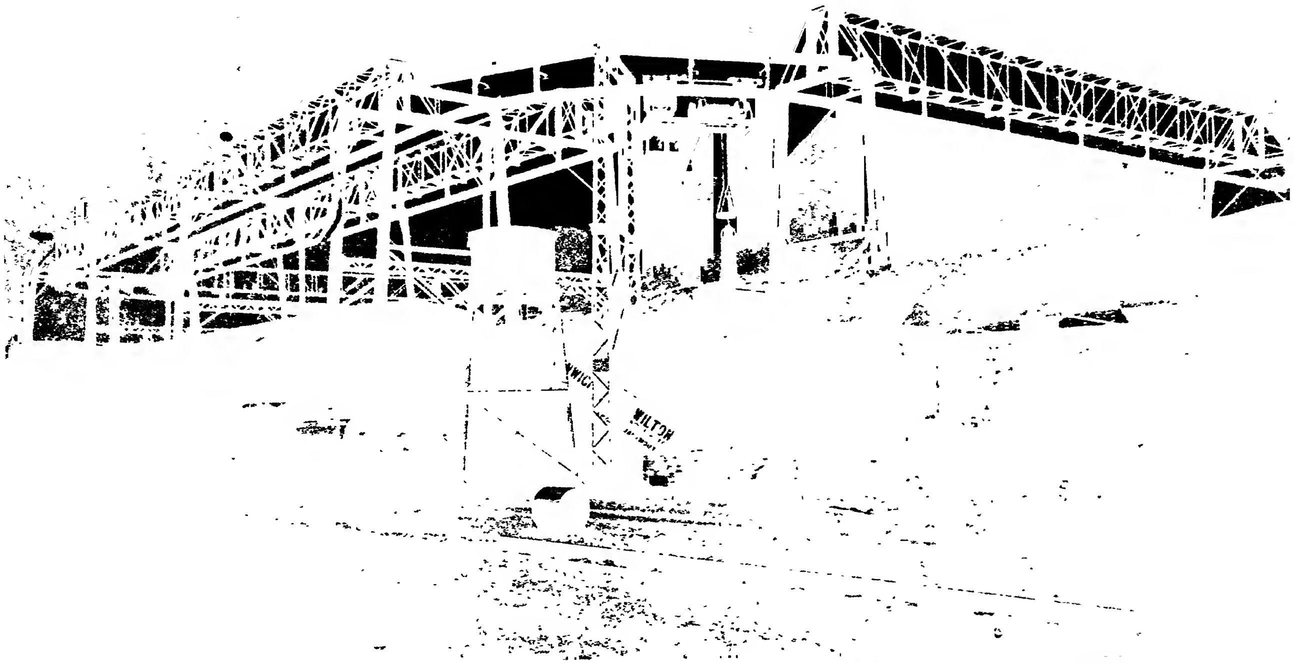

Mono-rail Telpher Installation at the Exeter Gas Works, handling 30 tons of coal per hour.
Erected by Messrs. STRACHAN & HENSHAW, LTD., Bristol.

MECHANICAL HANDLING OF MATERIAL AND ITS NATIONAL IMPORTANCE DURING AND AFTER THE WAR.

By

GEORGE FREDERICK ZIMMER, A.M.Inst.C.E.

With 134 Illustrations and 10 Collotype Plates.

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1917

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LIST OF COLLOTYPE PLATES

Handling Material by Labour Saving Appliances During and After the War.

By George Frederick Zimmer, A.M.I.C.E.

IF it is a truism that the national economy of the civilised world cannot do without the machine for handling and storing its raw materials and its fuel, it is doubly so at this time when the toll claimed from the ranks of labour by the European War has more than decimated the staff of many an industrial establishment.

We should bear in mind that theoretically a manufacturer is justified in laying out capital to the extent of £1,000 for every man he can replace by machinery, and in practice if driving power, supervision, lubrication, interest on capital outlay, depreciation and repairs are taken into account, an outlay of approximately £750 per man replaced, appears to be well within the province of a commercial transaction, but there is not even any necessity for such a capital outlay to save the labour of one man, as such an amount spent is more likely to release five or six labourers The present time no doubt bids opportunity of investing capital with ample security and at a tempting rate of interest; but, notwithstanding this, it is absolutely sure that capital invested judiciously now by the manufacturer in labour-saving machinery will not only yield infinitely higher returns than such investments, but it will be an act of patriotism as well.

The principal object of this series of articles is to induce those in responsible positions in ammunition and other industrial establishments to replace every available man by the machine, and in order to enable them to do so examples of systems and executed plants will be brought before their notice, and it is hoped that some of these examples may be found applicable, though perhaps with modifications suiting local conditions, to existing industrial establishments for the benefit of the owner and the country at large.

The installation of the plants and machines described and illustrated in this series of articles have effected or will effect a saving of workers, ranging with the nature and importance of the plant, from a single unit up to as many as 250 men, or more than sufficient for a company of infantry. The actual saving of hands in any industrial plant cannot always be pointed out with certainty, and it is therefore often omitted for that reason and to avoid tautology, but the saving of labour units in all plants is often too obvious to need comment.

All the installations described and advocated are on approved methods well beyond the experimental stage, so that they can be recommended with confidence. Large schemes for new installations have been avoided, as they are probably out of place during this crisis, and the subject has been confined more or less to smaller auxiliary plant which may be erected either in existing factory buildings or in close proximity to them.

Most of the mechanical devices for handling material in bulk are

well known, no doubt so well that they need not be described or even enumerated here, but there are new applications of familiar systems of handling which deserve more than a passing remark.

PNEUMATIC HANDLING.

The first of these appliances is the pneumatic system invented by F. E. Duckham in the closing years of last century, one of the most epoch-making innovations on all known systems of handling, a system in the application of which the material to be handled does not come into contact with the multiplicity of working parts, as is the case with most elevators and conveyers. The pneumatic elevator sucks the material through a nozzle and a series of pipes, say from the ship's hold, to an elevated canister, from which it leaves via an air trap to its destination, an exhauster furnishing a partial vacuum by pipes connected with the said canister; an ideal conception of essentially British origin which has in the last two decades received the sincerest form of flattery from competitive nations.

It is true that those who have exploited Mr. Duckham's invention have left the marks of their ingenuity upon the details of the system. When we consider that owing to the initial advantage of the system, already mentioned, it can be used for hard and cutting substances with better results than any other conveyer, or elevator, it is amazing that for practically twenty years it was only applied to wheat and other grain, which is easily handled by any other conveying appliances, so that one of the principal benefits was lying fallow. But now we can record the application of the Duckham system to ashes from boiler-houses, to coal from the railway siding or the stockheap to the boiler-house, to the conveying of fine cement from the silos to the packing room, besides the handling of chemicals, potatoes, green malt, etc.

The Darley system, the name by which the pneumatic handling of ashes is known, is an achieved success. It is exploited by the Guarantee Construction Co., of New York, and they have numerous installations at work, including plants for the United States Navy Department. As far as the writer is aware, there are no such plants at work in this country for handling ashes, coal, and other hard and cutting substances which reduce the life of ordinary conveyers materially without being detrimental to pneumatic plant except to a negligible extent.

A diagram of an installation, on the Darley system, for handling coal and ashes in connection with a boiler-house of the Baldwin Locomotive Works, is shown in Fig. 1 The railway truck is shown over the receiving hopper from which the coal passes over a reciprocating feeder, through a pair of crushing rollers to reduce it to a more uniform size, the suction pipe receiving it just below these rollers and delivering it into the 75-ton silos above the boilers. from where it is distributed by a travelling weigh-hopper to the different boilers The ashes from each boiler accumulate in small hoppered receptacles, and are let out at intervals into the suction pipe of the ashes conveyer, and finally into the 30-ton ash hopper, from which they are let out into some of the empty coal trucks. All this is clear from a glance at the illustration, as well as the exhauster and dust collector in the small lean-to.

In this respect it should be mentioned that in a pneumatic elevator the material floats, so to speak, in a current of air, from which it is separated at the delivery point (the canister). To ensure the material floating more or less in and with the air, it is essential that the air should travel faster in the conveying pipes as the specific gravity of the material to be handled increases, other-

wise it will have a tendency to separate from the air during travel, thus blocking the pipes, especially the portions which are horizontal or nearly so. As very considerable power is necessary to propel air at a greater speed, it is obvious that installations for heavy materials such as coal and ashes require more powerful pumps.

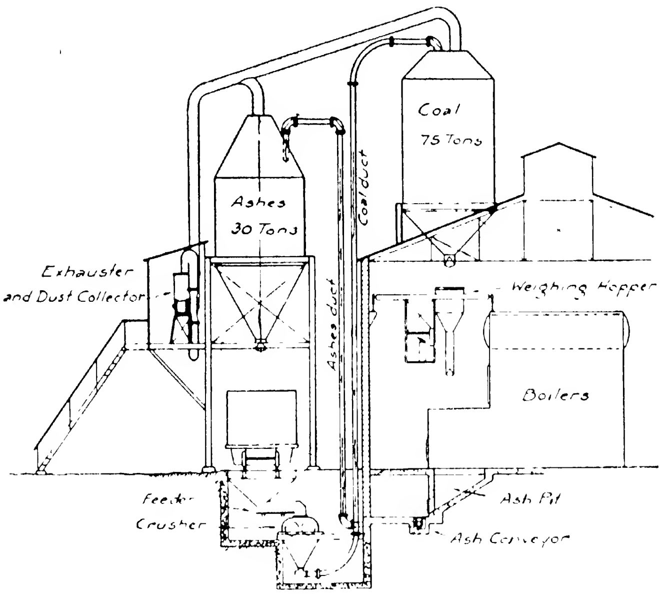


FIG. 1 SECTION COAL AND ASHES HANDLING PLANT AT THE BALDWIN LOCOMOTIVE WORKS, EDDYSTONE, PA., U.S.A.

Besides the pneumatic plant being superior to ordinary conveyers for the above purposes, what an army of men could be replaced, because even if an establishment has sufficient enterprise to install an ordinary conveyer for its ashes, it generally takes some hand-labour to shovel the material on, while with a pneumatic installation it need only be raked into an opening in front of each furnace. It is true that a gravity bucket conveyer, which often simultaneously feeds the coal bunkers over the boilers and collects the ashes from under them, is quite automatic, but the use of such a conveyer with its delicate parts for such rough work as handling ashes is a very wasteful policy. As a matter of fact, the difficulty of ash-handling has in this country often been solved along the line of least resistance, i.e., the work has been left to the man with the shovel and wheelbarrow, who might be more advantageously employed at all times, and more than ever now.

What has been said with regard to the mechanical disposal of ashes from boiler-houses applies equally much to the stokeholes of steamers, and it must be admitted to the ship-owners' credit that they are more enterprising in that respect than their colleagues on shore. The appliances used afloat are principally on the pneumatic and hydraulic principle, and the most important of them have been described and illustrated in CASSIER'S of August and November, 1912.

Apart from its special utility for

handling hard and cutting substances, the pneumatic unloader is extending its usefulness to the handling of wheat and other grain in small establishments. It should be borne in mind that at the introduction of the system it was only available to big establishments owing to the great initial cost of such installations, and the excessive consumption of power as compared with that necessary for ordinary bucket elevators. In spite of the latter circumstance, the flexibility of the system and the ease with which all corners of the ship's hold can be reached for removing the grain, its installation was found lucrative owing to the saving of the very expensive trimming necessary with all other modes of discharge. However, the improvements achieved, particularly in the direction of the choice of more suitable types of exhausters, have reduced the consumption of power considerably. Whereas it took 3 h.p. per ton of grain handled per hour it can now be done with less than 2 h.p. This, together with other improvements, has brought the system within the reach of any enterprising miller, maltster, or corn-merchant, who can now avail himself of an efficient pneumatic plant to transfer his grain from the canal barge direct into his granary with a minimum of expense. Such plants are executed on the latest lines by Henry Simon, Ltd., of Manchester, who exploit the patents of A. H. Mitchell, the Bulk Grain Engineer of the Port of London Authority. One of the latest plants of small capacity has recently been installed by Messrs. Simon for John Jackson & Sons, Salford (see diagram, Fig. 2). This plant has a capacity of 50 tons per hour and unloads barges on the Manchester Ship Canal. The vacuum pump is of the

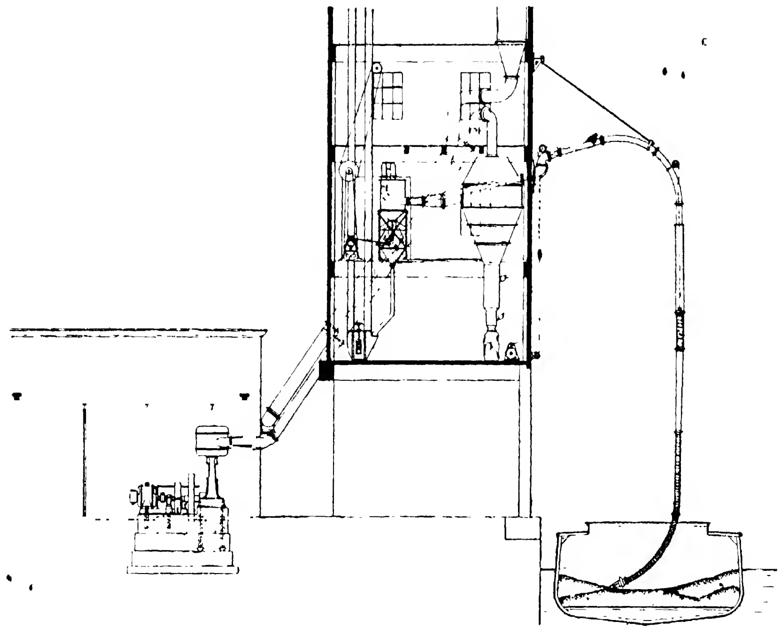


FIG. 2—GENERAL ARRANGEMENT OF PNEUMATIC GRAIN-HANDLING PLANT

vertical piston type and electrically driven. The particular features of interest are the air trap (Fig. 3) and the telescopic grain pipe (Fig. 4). The pump gives a high efficiency with a low vacuum or small pressure difference of some 7 in. to 8 in. of mercury, the speed is 135 r.p.m., and the electric motor driving it is of 80 h.p.

The air-trap or tumbling-box resembles the original Duckham trap, but instead of being loose fitting so as to tip over automatically as each chamber of the trap is full, the new type is operated mechanically. This has the advantage that a better fit is obtained, and therefore a smaller loss of vacuum, and also that stoppages of the tumbling-box owing to sticks and straws getting between the fitting surfaces of the box and its seating are avoided. The tumbling-box G (Fig. 3), is divided into two chambers J and H which are alternately brought into register with the grain outlet K at the base of the canister. It will be seen from the illustration that in the position of the trap as shown the chamber J is receiving the grain and is in communication with the vacuum in the canister and the door L is therefore held tight by the pressure of the atmosphere. The chamber H is discharging, the vacuum having been destroyed by the port opening seen at the top right-hand corner beyond the casting M. The ports N are connected with the main vacuum pipe, which produces a partial vacuum alternately in the com-

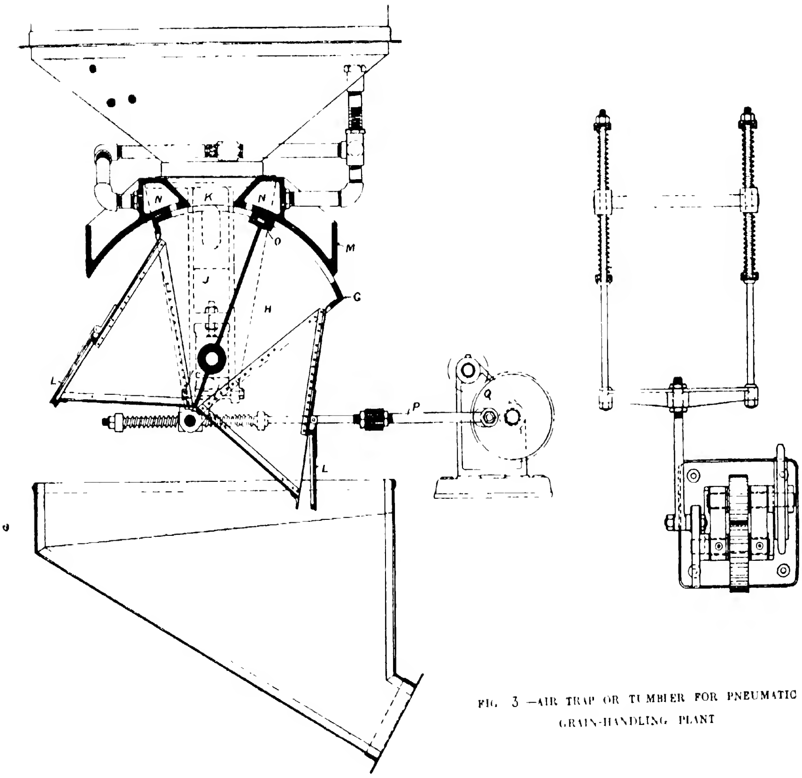


FIG. 3 —AIR TRAP OR TUMBLER FOR PNEUMATIC GRAIN-HANDLING PLANT

partments J and H prior to their communicating with the outlet K, to prevent a sudden inrush of the air from the compartments into the canister, which might disturb the normal flow of the grain. There is a packing strip O provided between the two compartments of the tumbler, held by springs against the upper face of the casting M. The rest of the fitting surfaces including the doors L

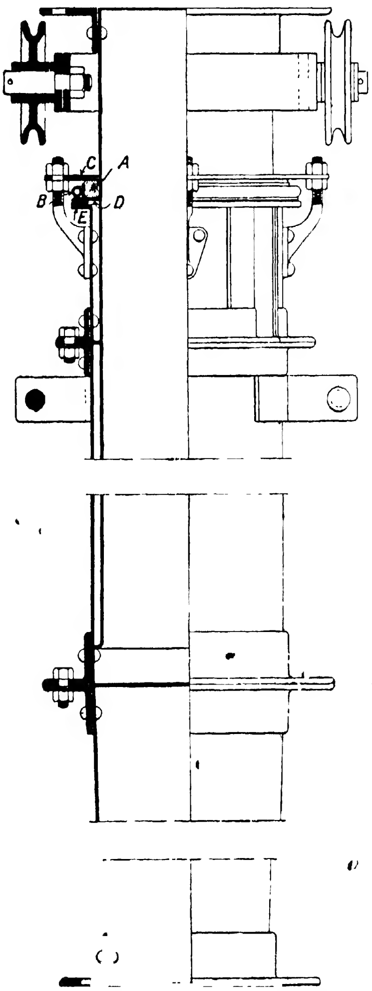


FIG. 4.—TELESCOPIC GRAIN PIPE FOR PNEUMATIC GRAIN-HANDLING PLANT

are leather faced. A crank and connecting rod P in connection with the mechanism operated by a train of spur wheels Q give the tumbler 10 tips per minute.

The telescopic pipe, Fig. 4, enables the operator to alter the height of the nozzle to the extent of 10 ft., as the level of the grain in the barge may change. The upper pipe slides inside the lower one in such a way as to prevent any grain entering between the joints. The packing joint consists of a ring of soft self-lubricating packing A held in place by spring B and flange C. The packing rests upon a loose ring D between which and the flanged end of the lower pipe is a rubber ring E. The lower portion of the pipe is raised or lowered by wire ropes over the two guide pulleys shown.

The suction nozzle is illustrated in Fig. 5. It consists of three parts, two of which form the duct for the grain whilst the third forms an inlet for the admittance of surplus air. This third section joins the two former pipes in such a way as to leave an annular air space. The amount of air admitted through this in excess of that entering with the grain depends upon the nature of the grain, whether specifically light or heavy, and can be regulated by a butterfly valve.

The *modus operandi* is as follows The vacuum created in the pump is connected by a 16-in. sheet steel main to the outlet of a cyclone dust collector fitted with discharge valve to permit the dust extracted from the grain to be sacked off. The inlet to the dust collector is connected to the grain-receiving canister, while the latter is in communication with the receiving nozzle in the barge by means of a series of rigid and flexible pipes (see Fig. 2). As soon as the pump is set to work and the receiving nozzle adjusted, the grain enters the canister tangentially, settles at the bottom of this receiver and is drawn off through the air trap to an elevator which disposes of the

grain to its final destination. The air and dust exhausted out of the canister pass to the pump via the cyclone dust collector, which latter eliminates the dust, so that the air is freed from the wheat dust which, owing to the silica particles it contains, is injurious, not only to the pump, but also to the lungs of the men employed. It is believed that the power consumed by this plan does not exceed 1½ h.p. per ton per hour.

intake pipes L are so made as to be readily connected and disconnected from the grain receiver F, whilst the receiver itself is suspended under the roof C, and travels on rails for some distance. The intake pipes are suspended from a runway D carried on brackets beyond the crane girder. With this provision the intake pipes may be turned round and swung clear of the crane when out of use. In this particular plant the air-trap G is of the revolving wheel

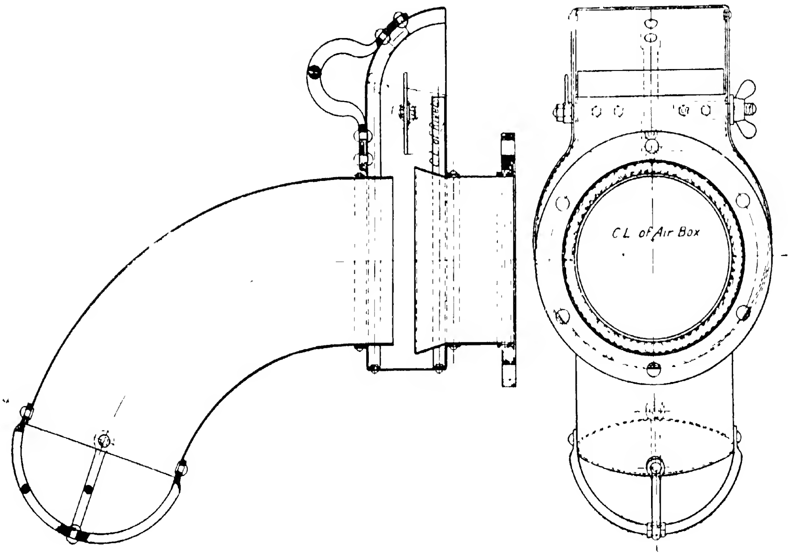


FIG. 5—SUCTION NOZZLE FOR PNEUMATIC GRAIN HANDLING PLANT.

Another interesting installation is that erected by the same firm of engineers at Carr's Flour Mills, Ltd., Silloth, which is capable of handling 75 tons of grain per hour (see Fig. 6). This installation is of special interest, as it shows the adaptability of a pneumatic plant to existing circumstances. The general principle is the same as in the previous plant, but it had to be so designed that it would not clash with or hamper in any way the working of an existing hydraulic crane A on the railway siding B. In order to get over the various obstacles the main

type, as there was not sufficient headroom for the tumbler trap previously described. The trap is operated by electric motor, the speed of which is reduced by double spur reduction gear, and it discharges the grain on to two band conveyers J which convey it to the silos.

ASH HOISTS.

With regard to the removal of ashes from boiler-houses, there are other mechanical means than the pneumatic method just men-

tioned, and moreover, such pneumatic plants would be too expensive for smaller installations. We will therefore investigate what further devices can be recommended, and to do so we must eliminate all plant of a complex construction, as ashes are so abrasive as to destroy very quickly any mechanical parts with which they come in contact, besides possessing other destructive elements, as the ashes may be hot or sopping wet. If hot, they will cause distortion and disintegration in the machinery of ordinary conveyers, and in pneumatic plants the draught may fan the glowing embers into flame, and if wet they will not convey in pneumatic plants, neither will they discharge from ordinary conveyers even if such could be accepted as suitable for the purpose. This reduces the applicable methods to a very narrow limit. Of what has been mentioned as ordinary conveyers only the push-plate conveyer of the U-link or some similar long-linked type, can come under consideration, but we will deal with these later. This leaves us with only three more types, which are the Grab, the Ash Hoist, and the Mono-rail, although frequently the ash hoist is fed by a mono-rail We will first deal with the ash hoist, or car and skip system, and leave the grab and mono-rail for subsequent description.

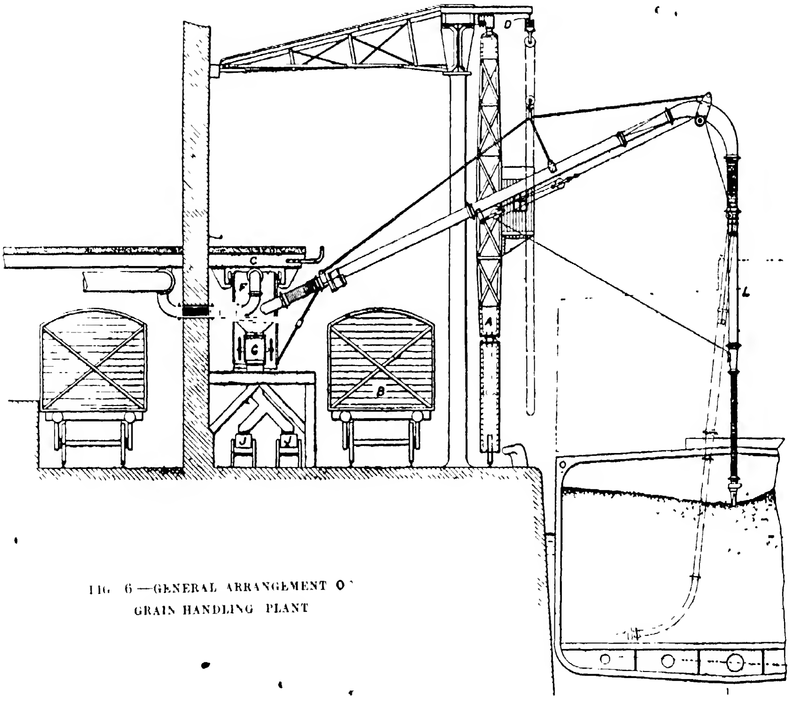


FIG. 6—GENERAL ARRANGEMENT OF GRAIN HANDLING PLANT

The ash hoist was probably first used on board steamers to raise the ashes and clinkers out of the stokehold, via one of the ventilating shafts. With stationary boiler plants on shore there was no need for a hoist in the early days, as the boilers were nearly always on a level with the ground, and at such time the coal consumption and consequent ash production was not

sufficiently large nor labour sufficiently dear to make it worth while installing an ash hoist. In the case of steamers it was different, as in the early days they could not take a short cut, as now, from the ash-pit through the bottom of the ship, and to get the ashes out of the way they had to be hoisted. The first hoists were of the most primitive form. A bucket, often on wheels, was pushed under one of the ventilating shafts and hoisted by tackle attached to some point of the rigging, and the ship's winch did the rest.

The hoist we recommend is a little more complex, but the one just described is undoubtedly its progenitor. The reason why the hoist is so infinitely more suitable for lifting ashes than bucket elevators is, that the material only comes into contact with a large iron receptacle in which it cannot do much damage by its cutting nature, by its heat, or by its corrosive wet condition. The ordinary bucket elevator, with its delicate chain constantly in contact with the ashes, would soon be on the scrap-heap, although it is theoretically more scientific to employ a continuous than an intermittent system of handling. Such an ash hoist is illustrated in Fig. 7. Below the ash-pit is an underground compartment in which the ash cars are filled by raising the doors of the hoppered ash-pits at such intervals as to get a full load. These cars are then tipped into the skip of the hoist, which comfortably holds the same load as the car. The skip when ascending is guided by three rollers and three rails on each side. One pair of wheels has a prescribed path which is purely vertical, and it will be seen from the illustration

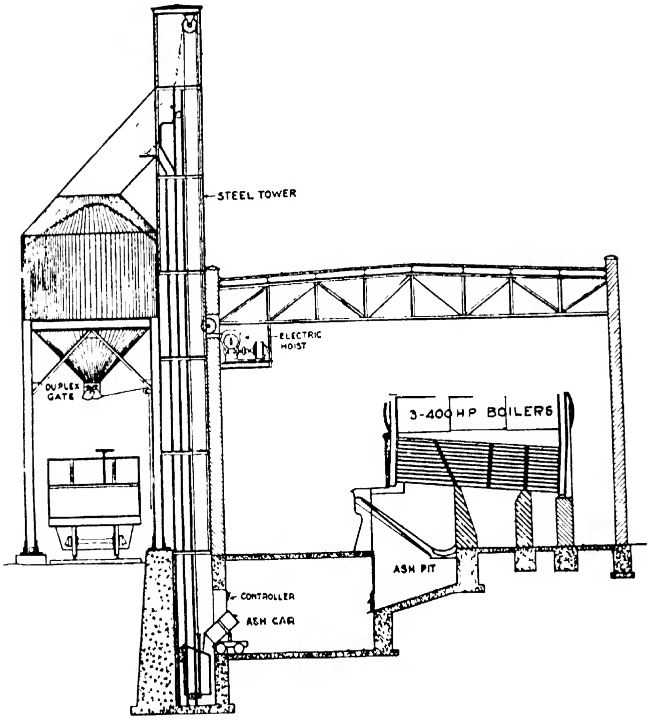


FIG. 7 REMOVAL OF ASHES FROM BOILERS BY SKIP HOIST

that this pair of wheels remains in both terminal positions between the same pair of rails. The other two pairs of wheels are forced by their rails to follow the same path until the top terminus is nearly reached, when they run forward and come to a stop before the first pair of wheels has reached the highest point, and the skip is, in consequence, tipped and so discharged into an overhead ash-bunker from which the ashes are removed at convenient intervals, generally into empty coal trucks. The skips may be of all sizes to suit varying installations, and hold from 20 to 50 cub. ft. The electrically-driven winch is seen in the boiler-house, from which a steel cable is connected by two sheaves to the skip The motor is geared to the winch by worm and worm-wheel running in oil, and a band brake on the armature shaft stops the motor promptly at the top and bottom of the lift, i e, in the two terminal positions The electric switch is controlled by a travelling nut on the drum shaft. Such hoists can be equally well driven by other motive power, for instance, if hydraulic mains are available, the skip can be raised and lowered by a reeved hydraulic cylinder, similar to any ordinary hoist.

A very neat example of an ash hoist is that of Trewent and Proctor, known by the name of Proctor's Self-Tipping Bucket Hoist This labour-saver was originally designed for the removal of ashes from steamers, but it is equally applicable for any boiler installation on shore This self-tipping bucket has been the outcome of experiments on a well-known principle, to obtain the best results with the least complication. The only working parts are guide rollers or pulleys, which cannot get out of order One man can fill the bucket and work the hoist from the stokehold floor level The illustration (Fig. 8) is almost self-explanatory. There are three cast steel brass-bushed guide rollers on each side of the bucket, and two wire rope guides, which pass between these rollers as shown, the upper end of each guide being attached to a cast steel plate or header.

When the bucket is lifted and has reached the upper terminal the

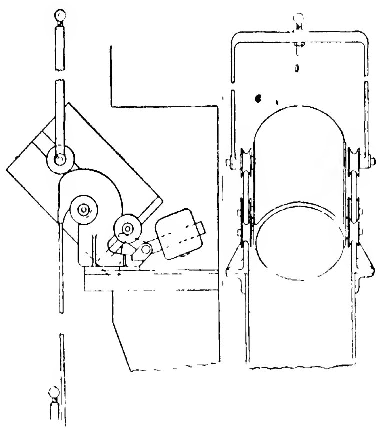


FIG. 8 — PROCTOR'S SELF-TIPPING BUCKET

middle pair of wheels engage with the slots shown in the headers, while the uppermost pair of wheels run round the periphery of the headers and thus cause the bucket to tilt and empty. The levers and weights shown are provided for floating installations, in case the vessel has a heavy list, when the levers will give the empty bucket sufficient impetus to return to the vertical position again. They also have the advantage of bringing the bucket gently to rest when tilting.

The hoist (Fig. 9) for manipulating this bucket is very simple in construction, easy to handle, and noiseless. It has a direct lift without any complicated gearing, and it is practically impossible to overwind or get out of order. It consists of two solid drawn steel tubes of different diameters, connected at the upper and lower ends to cast-iron chambers which carry the two ter-

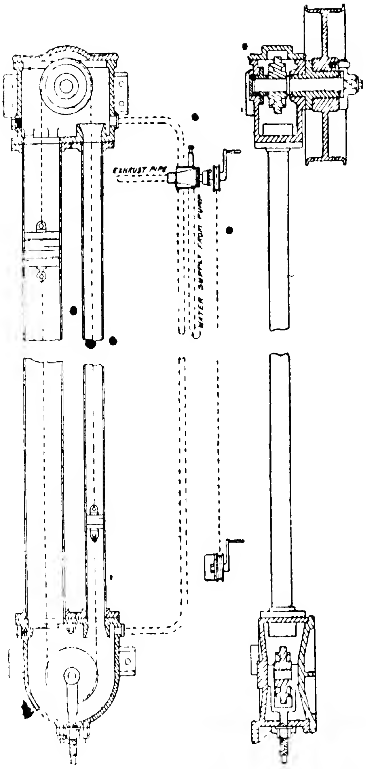


FIG 9.—HOIST FOR MANIPULATING PROCTOR'S SELF TIPPING BUCKET

The tubes are galvanised inside and out by a process which leaves the interior quite smooth. Stops at the upper and lower ends of the larger tube prevent the piston from coming out too far.

If pressure water is admitted into the upper chamber the larger piston will descend, or conversely, if the water is admitted into the lower chamber it will rise, causing the chain to travel and rotate the top sprocket wheel, which communicates its motion to the winding drum, which in turn either raises or lowers the bucket connected to it by a wire cable. No expensive fittings are required, as the power needed is only of low pressure such as can be furnished by any convenient donkey pump in the engine-room, capable of standing, say, 100 lbs pressure per square inch, or from a hydraulic main. The largest size hoist only requires a 1½-in. water supply pipe from donkey pump to hoist control cock, and a 1¼-in. pipe from control cock to hoist.

When required to raise ashes, all that is necessary is to start the donkey "crawling," when sufficient power is generated for working the hoist. It is usual, when self-tipping buckets are discharging down a shoot, to use a small supply of water for keeping the shoot clear, and this water can be made to work the hoist

minal wheels. An endless chain with flat links, equal to a working load of one ton, runs through both tubes and round the wheels like the chain of a bucket elevator. In each tube is a piston fitted with double cup leathers and connected to the chain, so that when the one is uppermost the other is in the lowest position.

The lower terminal is simply held by a tightening screw, while the upper one has a spindle which projects through the cast-iron casing, and to this spindle the drum is keyed for winding up the wire rope which lifts the bucket.

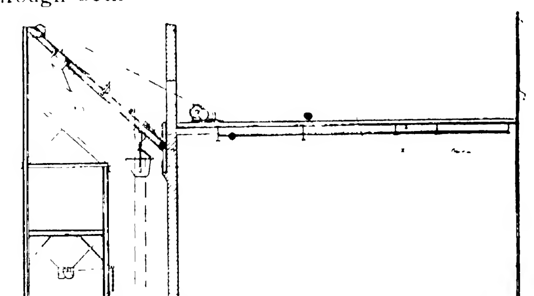


FIG 10.—ANOTHER TYPE OF ASH HOIST

before being turned into the shoot. By means of the two starting levers shown in the illustration the hoist can be manipulated either from above or below.

A type of ash hoist in which the bucket is of a somewhat different construction, and in which the path is prescribed by two girders placed obliquely above the hoist, is shown in Fig. 10. The skips are provided with a loose bogie, so that they can be pushed under the ash hoppers, filled, and pushed back into the hoisting position, when the skip is lifted off its bogie and raised till it touches the oblique track, which it now follows until a tripper is encountered at the dumping point, which causes the skip to empty. The skip is supported below its centre of gravity and held upright by an oblique arm at the back, and it is this arm which is pushed out of the way by the tripper. The position of the electrically-driven winch in the boiler-house is shown in the illustration. Very neat ash hoists are made by The Chain-Belt Engineering Co., of Derby, and by Robert Dempster & Sons, Ltd., Elland.

MONO-RAILS.

Trucks with four wheels and running on two rails for handling ashes from boiler-houses, and, in fact, in practically all industries, are rapidly being superseded by the Mono-rail. The rails of the former being on the ground are very much in the way of other traffic, especially in congested passages and factory rooms. The overhead mono-rail, from which the vehicles are suspended, is a little more expensive to install, but it occupies space which is generally of less value, and there are cases in which conditions obtain which involve the absolute necessity of transport at a considerable height from the ground so that there is a good deal to be said in favour of suspended overhead traffic. The culminating point of the overhead system is reached in the telpher, but under mono-rails we will here consider the humble progenitor, the hand-pushed suspended receptacle, which can save many a man as compared with transport on four wheels and two rails.

Among the obvious advantages of this system are the following :—mono-rails (*i.e.*, the rails themselves), being out of the way of other traffic, remain clean and un-

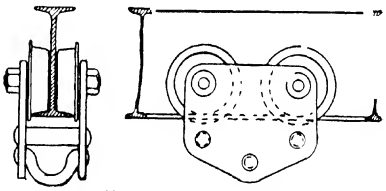
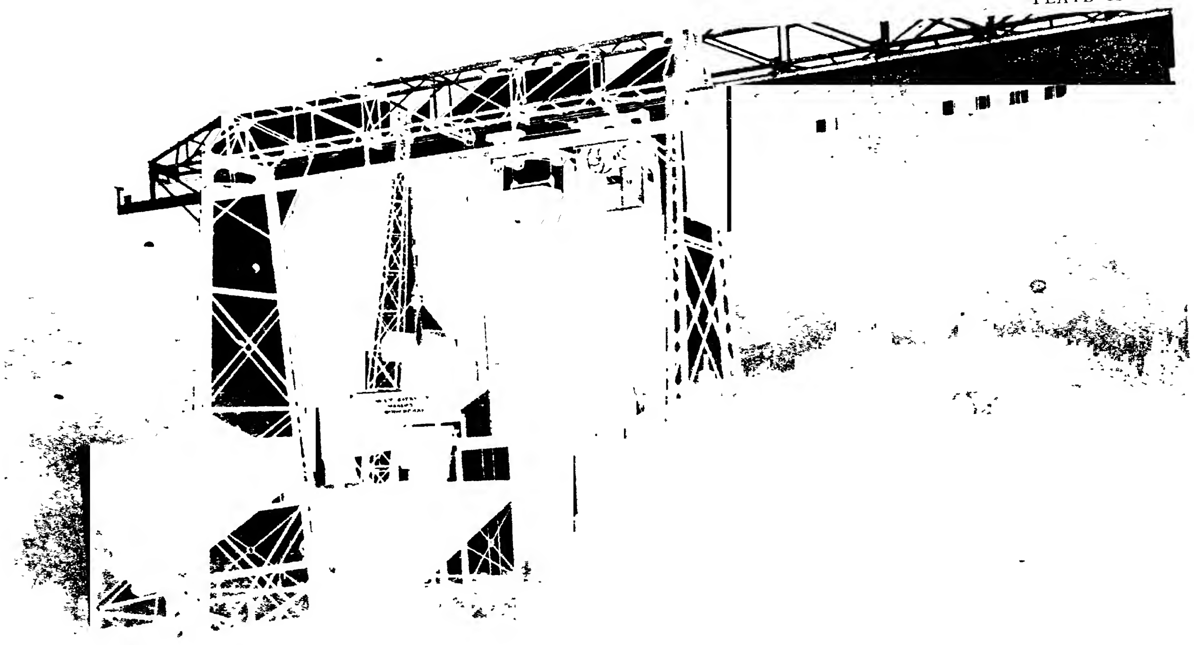


FIG 11 —TRAVELLER OF MONO-RAIL

obstructed, and therefore offer less resistance to the movement of the vehicles, and the latter having generally only two wheels, run more easily than four-wheeled receptacles, as the friction is less. The condition of the ground, whether level or otherwise, does not influence the construction of a mono-rail system, and the floor is unobstructed by rails, turntables, etc.; the vehicles can either be suspended sufficiently low for a man to push whilst walking on the ground, or so high up that they do not interfere with other traffic, or with obstructions, such as plant or machinery, on the ground.

The track may be supported from the ceiling or other part of the building, or from constructional iron or woodwork. It may negotiate sharp curves and gradients, adjusting itself to most requirements. In small installations the track may be a light rail section, or may consist in its simplest form of a flat iron bar, the vehicle being suspended from a two- or four-wheeled trolley upon these rails (see Fig. 11). If the point of suspension is too high above the ground for manual propulsion the line may be laid so as to work by gravity if it is only required to transport goods in one direction. For large installations the rails are

PLATE II.



Avery Automatic Hopper Totaliser at Blyth's Wharf London
Erected by Messrs W & T. AVERY LTD., Birmingham.

of more substantial section and the supporting girders are correspondingly heavier; a small suspended locomotive can even be used to pull a train of vehicular receptacles.

An application of the mono-rail skip for removing ashes from boiler-houses is shown in Fig. 12. In this installation the ashes are brought some little distance through a tunnel and shot into an ash hopper by tipping the skip, which is suspended below its centre of gravity. From this hopper the ashes are removed to a railway truck by a telpher with hoisting gear. The skip from this is lowered by the hoisting gear, and the man above fills it by letting down the shoot from the outlet of the ash hopper by a rope. When the skip is loaded, the shoot is raised again and the hoist started, lifting the skip to the top, when the travelling gear of the telpher comes into play, conveying the skip over the truck in the position shown in the illustration, where it is tipped.

Having now dealt at some length with the disposal of ashes, we will see what labour can be saved in bringing and storing coal as close as possible to the boiler-house.

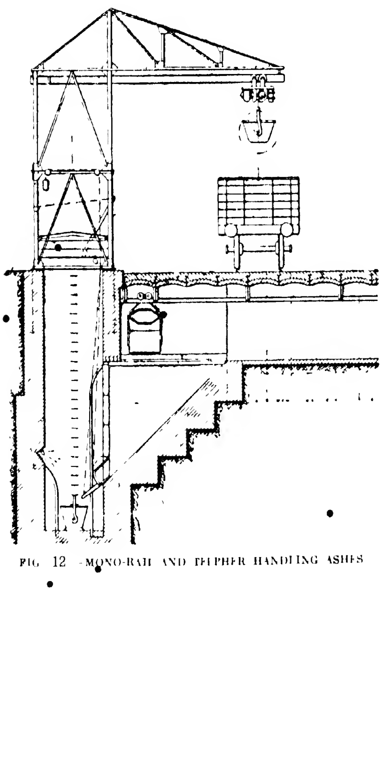


FIG. 12.—MONO-RAIL AND TELPHER HANDLING ASHES.

THE STORING OF COAL.

An open stock-pile or heap as a main store for coal, from which smaller secondary elevated accumulations of coal are replenished, is an important asset in all large industrial enterprises, and therefore deserves the closest and most careful consideration from many standpoints. In this country, where the industrial centres are in comparatively close proximity to the coalfields, it may appear, and rightly so, that it is unnecessary to keep so large a stock of coal as it is in America, but the stock-heap is like an accumulator, which can be added to when circumstances are favourable, and from which coal can be withdrawn as required, and particularly so when strikes, lock-outs, breakdowns in collieries, and *force majeure*, as well as the state of the market, make the supply unreliable or impossible. The larger, therefore, the stock, the less the likelihood of a stoppage for want of fuel or raw material. This applies more particularly at this present crisis, though it applies to a lesser degree at all times.

An ordinary heap of coal devoid of appliances for reclaiming it without shifting it by hand labour is, with certain reservations, a makeshift and one of the greatest extravagances, for each time coal is handled it deteriorates in value, and particularly so when shifted by the most inefficient means for the purpose—the man with the shovel. When coal has once been raised in any kind of receptacle, or by any mechanical device, it should either be retained in that elevated position in such a way that it can be withdrawn (simply by opening the gate of a shoot) by gravity—like water from a tank—or it should be accumulated in a way in which it is automatically accessible to conveying machinery without the aid of the human element.

Now the difficulty in following this fundamental principle is not great for small establishments. They

have, or should have shall we say, overhead bunkers above their boilers or retorts, large enough to receive a weekly supply, or a supply at certain regular intervals, which is paid out and distributed as wanted to the boilers, etc., so that at the end of the period in question the bunkers the rainwater can drain off. The accompanying illustration, Fig. 13, shows such piles on the trestle system. This system employs two parallel trestles of moderate elevation, say 10 to 15 ft., and about 30ft. apart, and a Link-belt standard gauge crane on one trestle lifts coal

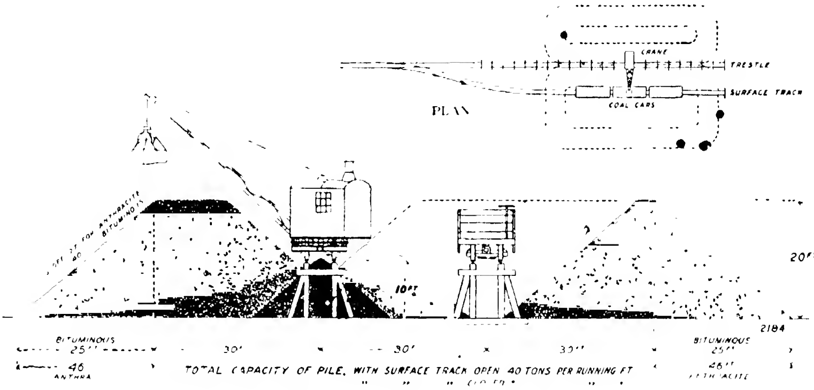


FIG 13 —TRESTLE SYSTEM OF STORING COAL

are exhausted, or if large enough hold a small margin. Where such a regular supply cannot be depended upon with absolute certainty, a main stock-heap as mentioned above is indispensable. Those who have made a convenience of the railway companies' trucks for holding their stock of coal will probably not be able to do so now

To hold very large masses of coal, such as would be necessary for a main stock, in suspension at a sufficient height, is a costly, nay almost impossible proposition. We will therefore see what judicious methods can be adopted to form a main stock in such a way as to be automatically accessible for reclaiming by mechanical means.

The first and simplest, and therefore least expensive, method is a plain heap accumulated on a cemented and well-drained space of any shape in the yard. Well-drained means, in this case, either on a gentle natural slope, or if the ground is quite level, slight artificial slopes leading to drains should be provided, so that in either case from cars on the adjoining trestle and store, as shown in the cross-sectional view. Where a trestle is already in use the construction of a short parallel length gives the advantage of cheap and automatic stocking and reloading, and adds materially to the storage capacity. The method of forming the heap is a separate subject dealt with later.

To withdraw the coal from such a stock can only be accomplished in two ways, firstly by crane or telpher and grab (this only to be recommended if it has been accumulated by these same means), or secondly by pneumatic suction plant (available however only for coal of small size). This latter system is fairly efficient. Suction mains are laid alongside the heap (which is in this case best with a rectangular base), on which tee joints are provided for the attachment of flexible nozzle pipes, which are conducted to the side of the heap by a man, like a fire-hose, only with the opposite effect. The pneumatic withdrawal has the advantage that the coarse and fine are taken together as they

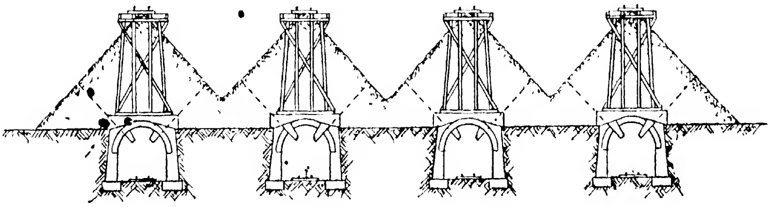


FIG. 14 STACKING COAL ON A LEVEL BASE.

lie, and with practically no breakage, whilst with the grab a certain amount of breakage is unavoidable, with the consequent accumulation of coal dust at the bottom of the heap, which may be conducive to spontaneous ignition, besides the reduced value of the coal and the fact that coal taken from the heap is not of average quality, that is, the last will contain much dust.

All other stock-heaps must be superimposed upon one or more tunnels or culverts, provided with suitable conveyers of the continuous or intermittent type into which the coal can be drawn through shoots communicating between the coal and the conveyer. These communications are fitted with slides, which are withdrawn by rack and pinion or by levers, or both, or in some other simple way.

The conveyers may be of any of the well-known band, push-plate, V-link, continuous trough, or gravity bucket types, while the intermittent conveyers may be small gauge railway trucks hauled by motors or ropes, mono-rails, or telphers, either of the latter two in conjunction with a ropeway if great distances have to be negotiated.

Now as to the base upon which such accumulations of coal can be stored, there are many methods, and the introduction of fortified concrete for such structures has widened the field of possibility considerably. The simplest method, but by no means the best, is a level base with a number of tunnels beneath, as shown in Fig 14. This can only be recommended for the intermittent types of conveyer, as the same rolling stock which brings the coal, be it surface trucks, telphers, or ropeways, can also be used in all or any of the tunnels, all the lines converging to one point near the boiler-house, so that it will only be necessary to lay suitable rails on the floor or ceiling, as the case may be, for the conveying methods already mentioned. This plan has the disadvantage that as the pile diminishes trimming will become necessary, as the coal will lie as indicated by dotted lines, when it ceases to run out by gravity. If we wish to avoid this trimming and make the store quite automatic we must give it a base as shown in Fig. 15. The illustration shows only two culverts, but there could be any number, and the hopper may be entirely underground, or partly above as shown. Fig 16 shows a single hopper base for a smaller stock-heap. The structures are composed of ferro-concrete, and buttresses will have to be provided at regular distances to carry any superstructure which may be required over the pile. The height and strength of such structure depends naturally on the method chosen, and it is patent that for a continuous type of conveyer like a band or push-plate, a lighter structure will suffice than for an intermittent type which carries larger individual loads. If, on the other hand, the pile is formed by a locomotive or travelling crane and grab, which can reach over from rails at the side to the centre of the pile, no superstructure whatever will be necessary.

To withdraw the coal from the

base of the pile is the most correct procedure. It has the advantages over the previous method that the coal which has been longest on the pile is withdrawn first, the small does not accumulate, and because the coal is frequently in motion through the removal of the lower

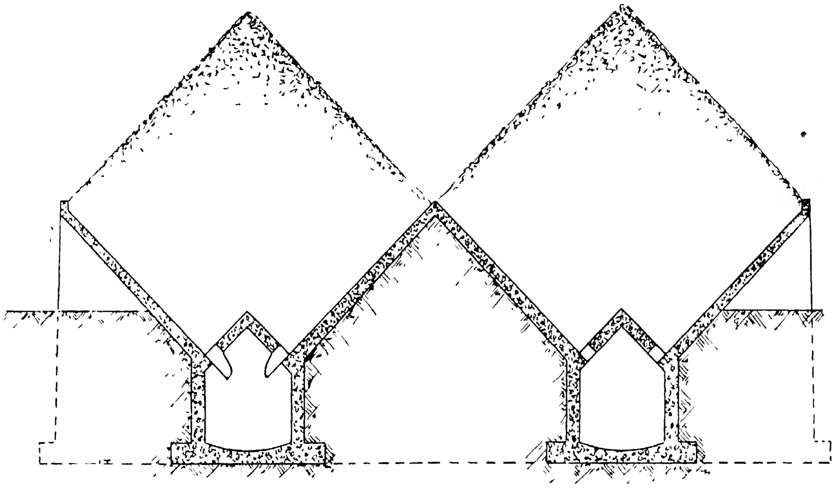


FIG. 15—STACKING COAL ON A HOPPERED BASE

layers spontaneous combustion is prevented, and the pile can, therefore, be raised with safety to a greater height.

As a rule it may be said that the greater the capital expenditure on the structure supporting the stock-heap, the smaller will be the expenditure for the mechanical appliances, and as the latter are subjected to deterioration by wear and tear, renewals, and breakdowns, from which the former are immune, it is more economical in the end, and the plant is less subject to stoppages if the expenditure on the structure is not stinted.

We come now to the delivery of the coal from the main stock to the auxiliary bunkers from which it will be drawn for use. This depends to some extent upon the nature of the ground and the proximity of the main stock to the final destination of the coal. It is obvious that the main stock should be as near its destination as possible, and in new installations no one who gives the matter a passing thought would lay his plan out otherwise, but have the main heap between the railway siding or the waterside and his boiler or retort-house. But unfortunately for the engineer (not the capitalist), big establishments have sometimes grown from a small nuc-

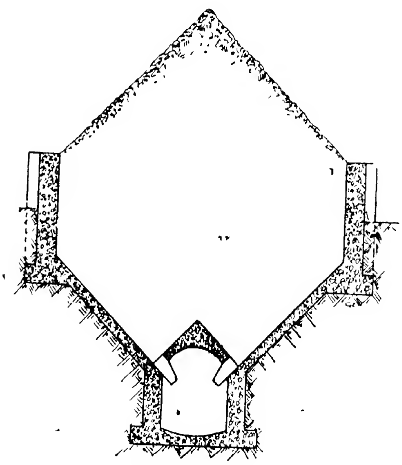


FIG. 16—STACKING COAL ON A SINGLE HOPPER BASE

ieus on a confined space, so that often additional land will have to be acquired for stock-heaps when matters do not arrange themselves quite so favourably. Fig. 17 shows a good installation by the R. H. Beaumont Co; the siding being close to the boiler-house and the other hand the distance between the stock-heap and the final destination of the coal is sufficiently great, a conveyer of the less expensive band, continuous trough, or U-link type, can be used in the same way, except that the ascent is oblique instead of vertical. Intermittent ap-

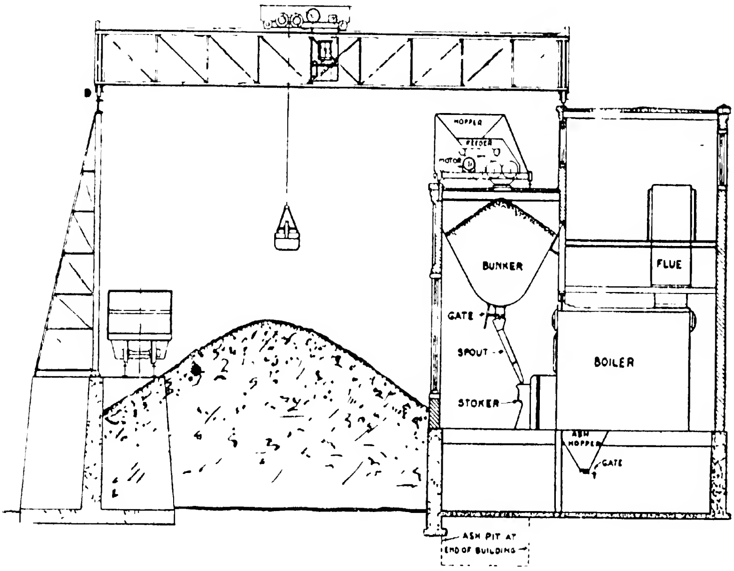


FIG. 17 COAL HEAP WITH BRIDGE GRAB CRANE

stock-heap between the two. The grab takes the coal to a portable hopper with coal-breaker for filling the bunkers. If the heap is in a suitable position, the best plan would probably be to choose a conveyer which can at the same time be used to ascend an incline sufficient to reach and traverse the top of the bunkers and discharge into them. We thus see that if the main stock-heap is quite close to the boiler-house, one of the more expensive gravity bucket conveyers or a V-bucket elevator should travel through the culvert under the stock-heap, take its load, and ascend vertically to the top of the bunkers of the boiler-house, and there finish by a horizontal run on top of the bunkers, and deliver its load. If on the

pliances, such as mono-rails and telphers, and even rope-hauled self-discharging trucks, can be used in the same way if a very gentle slope is permissible for the rise of the receptacles to be discharged.

Less convenient and more expensive in initial cost, as well as in depreciation of the coal and wear and tear of the plant, is the use of more than one conveyer and elevator. This applies principally when the distance becomes too great for one conveyer, or combination of conveyer and elevator. In such cases an intermittent system (one of those already mentioned) may be used to bring the coal from the main stock to the boiler-house, and there deliver its load into a gravity bucket or similar conveyer which raises and

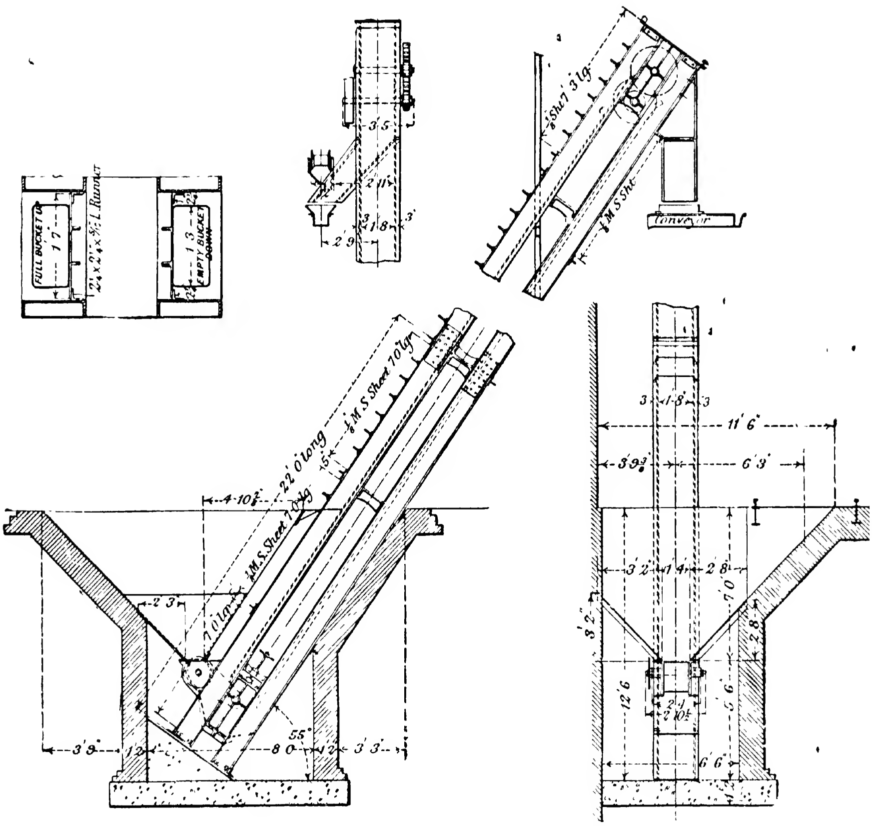


FIG. 18.—TYPICAL COAL ELEVATOR FEEDING A U-LINK CONVEYER

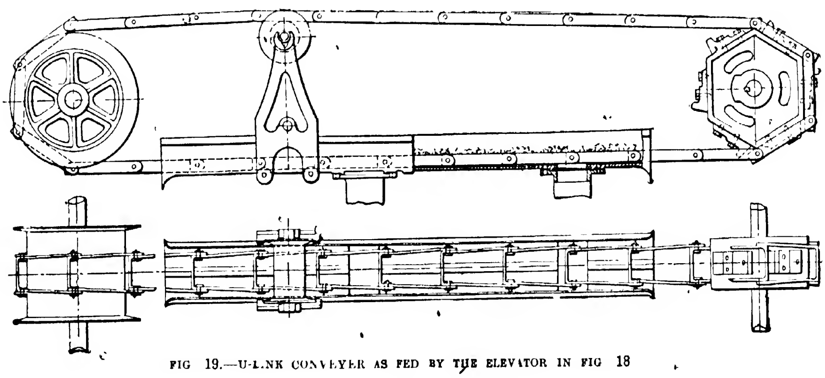


FIG. 19.—U-LINK CONVEYER AS FED BY THE ELEVATOR IN FIG. 18

at the top, distributes the coal into the various bunkers, or a separate bucket elevator and a separate conveyer may be employed to fill the bunkers. Figs. 18 and 19 show a bucket elevator and U-link conveyer of Messrs. Ed. Bennis & Co., Ltd., in use at the Electricity Station, Southend-on-Sea.*

In concluding the subject, we have still to consider the delivery and accumulation of the coal from the barge or railway truck to the stock-pile. If the coal arrives by barge it is unloaded either by grabs in conjunction with a crane or telpher, or by a suspended bucket elevator, and lifted to a convenient

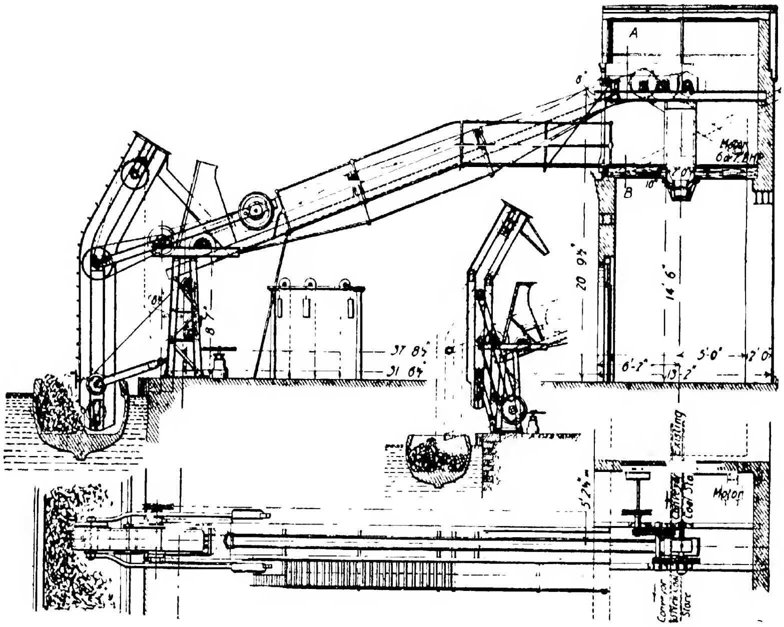


FIG 20.—SIDE ELEVATION AND PLAN OF BARGE ELEVATOR CONVEYER AT COVENTRY CORPORATION ELECTRICITY WORKS

This practically disposes of all the usual methods which will, however, be more fully illuminated when we deal with the boiler-house proper. It is now only necessary to be mentioned that when withdrawing coal, as in the first instance by grab or pneumatic means, a conveyer or elevator, or a combination of the two, is likewise necessary to deliver the coal into the bunkers; at any rate, it is unavoidable in the case of the grab, while with the pneumatic plant it can be avoided by building a tower-like erection above the bunkers to accommodate the terminal plant of such installation.

height at which it can be conveyed, generally by narrow gauge self-emptying trucks, to the top of the stock-pile. What is known as a barge elevator is very frequently used in place of the hoist and grab. Such an appliance is illustrated in Fig. 20, which is at work at the Coventry Corporation Electricity Works,* and was erected by Messrs. Ed. Bennis & Co., Ltd.

The elevator consists of two dust-proof trunks each constructed from two 10 in. by 3 in. channels and two 17 in. by ¼ in. plates, which makes a very substantial job.

The two trunks are bent as shown

* Fully described in "Engineering," of October 30, 1914.

* Fully described in "The Engineer."

in the illustration, and connected at either end to the usual elevator terminals. The outer trunk accommodates the loaded rising strand of buckets, while the return strand descends by the inner trunk. Rungs are riveted to the outer trunk to form a ladder for access to the driving terminal. The elevator is suspended above its centre of gravity by two sets of parallel arms, the upper set with heavy balance weights, so that the machine can be adjusted easily up or down in the barge by turning a handle fitted to the spindle of a worm which gears into a toothed quadrant. The parallel levers are pivoted on the land side to a pilaster constructed of 6 in. by 3 in. channels and strongly braced together. The elevator chain is of the double-link type, and the buckets are of mild pressed steel, and 12 in. wide. Like all barge elevators, the lower terminal is not enclosed, so that the coal can enter the buckets freely, and the chain is kept taut by the usual tightening screws at this end. The elevator terminal wheels are hexagonal. A steel shoot secured to the upper terminal discharges the coal into a hopper, irrespective of the position of the elevator or barge (the illustration shows the elevator in its lowest position), and from this receiving hopper the coal is delivered on to a Bennis U-link conveyer with a slight ascent. The trough of the conveyer is of cast iron, and 9 in. wide by 6 in. deep by ⅝ in. thick. In this installation an automatic weighing machine is used at this point, so that a record of the coal received can be kept. Before this plant was installed manual labour was employed, when the coal was raised by hand and thrown into the store, and since its erection the saving effected in the transit from barge to boiler-furnace is 60 per cent. In a stock-pile or coal-silo house the U-link conveyer would reach right to and over the pile or silos instead of terminating where shown in the illustration.

In a few isolated cases where the works in question and the colliery not far distant are under the same control, the fuel may be brought by a ropeway which would deliver automatically on the top of the pile, but this is so rare an occurrence that the proposition might almost be ignored.

If the railway siding should be or can be brought high above the ground level, it may be possible to bring the rails right along the centre line of the main pile high up, and so deposit the coal by self-unloaders. This is an ideal solution, but unfortunately not often possible.

The only other proposition is to empty the railway trucks either by tip, or by the use of self-discharging wagons, into a pit from which the coal is raised by a continuous elevator and conveyer (to be more fully described under the heading "Terminal Plant"), or by any of the intermittent handling devices, to the top of the heap. This means a steel structure on the top of the hoppered concrete base of the stock-pile. A travelling crane running on rails with a clam-shell bucket, on one or both sides of the pile, which grabs the coal out of the aforesaid pit, travels along the pile to deposit its load wherever the heap wants replenishing. With this arrangement the coal can be reclaimed either as deposited, by grab, or *via* the tunnels by other conveyers. One of the best intermittent conveyers for this particular purpose and not yet mentioned is the Hunt automatic railway, which can be used in connection with coal unloaded, as stated, from railway trucks, or it can be charged *via* a small receiving hopper from a crane and grab, as taken from a barge. The Hunt automatic railway is not so well known in this country that a short description of it would be out of place here.

This automatic railway is now in general use in America. In this country it is built by Messrs. Babcock & Wilcox, Ltd., and a few of the more important installations here are, at the Avonbank Power

Tray Conveyors of horizontal and tipping-tray type; capacity 60 tons of coke per hour.
Erected at The Gas Light & Coke Co's Works, Beckton, by Messrs. BABCOCK & WILCOX LTD., London.

Station, Bristol; the United Tramway Power Station, Dublin; the Gas Light & Coke Co., London; and the Lancashire Power Co., Radcliffe. It consists of an elevated self-acting railway operated entirely by gravity; there is no steam, horse or manual power required in its working. Its chief peculiarity consists in storing sufficient energy, which has been acquired by the loaded car descending the inclined track, and which, after the load has been discharged, is utilised to return the empty car back to the place from whence it started. It is limited to a run of about 500 ft., and the incline of the track is about 3 per cent. It is perhaps at its best for distances not exceeding 400 ft., and capacities of 60 tons per hour.

The coal is hoisted from the boat, either by steam or electric power, and dumped into the car by an attendant. It takes the entire attention of one man to operate the railway, who loads the car and starts it by a slight push. The car runs down the track, deposits its load at any predetermined point, and returns to the hand of the workman The workman does not accompany the car.

The car runs with great rapidity, making, for instance, a trip of 300 ft, discharging its load, and returning, in about 50 seconds. The car is entirely automatic, and requires no attention whatever from the time of starting with its load until its return empty, ready for another load.

By the time a loaded car has reached the end of its journey it has automatically raised a counterbalance weight to a certain height, by means of a tripper and steel wire cable, which the car picks up while running down the track. After the load has been automatically dumped the now empty car receives an impulse by the sudden descent of this balance weight, which is sufficient to return it back up the gradient to its starting point. The weight rises only a limited distance, the object being to give the car a start back, and the momentum carries it the remaining distance. Care has to be taken to make the raising of the weight a gradual movement, so that as few sudden strains as possible are brought on the various parts of the mechanism. The returning weight can be placed at any part of the track most convenient, and may be boxed in and coal piled around it; it needs no attention whatever.

The cars used (see Fig. 21) are of wood and iron lined, or entirely of

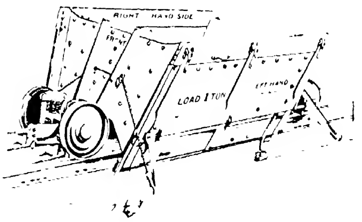


FIG 21 CAR OF HUNT AUTOMATIC RAILWAY

steel, and they discharge the load by opening the sides by means of a tripping block placed on the track, letting the coal run out on each side. The bottom has a ridge in the centre, so that the material runs entirely out. The sides are fastened, not to the car, but to each other, so that if one is unfastened, both are. The load is always discharged evenly and without danger of overturning the car, although it is a very narrow gauge. The bearings of the car are somewhat peculiar, as they are so arranged that it runs round a curve of 30 ft. radius, theoretically as easily as on a straight line, and practically nearly as easily.

The gauge of the track is 21 in. from outside to outside of rail heads. The steel wire rope that raises the weight is detached from the car except during the time that the latter is raising the weight and receiving the impulse to return; this permits the loading end of the track to be curved to a radius of 30 ft. Fig. 22, which illustrates the arrangement of tracks over a coal yard, will show that this system can be adapted to almost any situa-

tion if the curves are confined exclusively to the loading end of the track, where the car still travels slowly.

The expense of storing coal by this system is equal to the wages of one man, and is the same whether a small or large amount is handled. The cost of installation is exceedingly small as compared with some

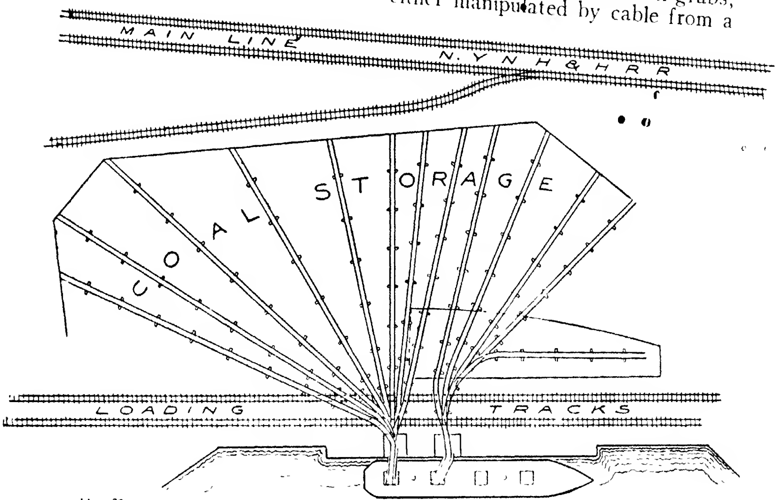


FIG. 22 PLAN OF THIRTEEN HUNT AUTOMATIC RAILWAYS, FROM TWO HOISTING TOWERS, NEW YORK, NEW HAVEN AND HARTFORD R. R. CO.'S LOCOMOTIVE COALING STATION AT NEW HAVEN, CONN., U.S.A.

more complex systems, and it is hoped that the dearth of labour will teach us the lesson of adopting a method which we have not learned in peace time.

Simple and efficient as this system is, it is only applicable for small coal on account of the violence with which the coal is discharged, but for such small coal as is generally used in gasworks and power-stations it is a most excellent and useful device. (This also applies to ores which do not suffer in value by breakage.)

The most usual method of assembling extra large main stock-piles is by means of transporters, also frequently named bridge or cantilever cranes. Such transporters are built by Fraser & Chalmers, Ltd., and Sir [illegible] Arrol & Co., Ltd. (Temperley transporter crane). These gigantic structures reach from the waterside where the coal barges, or more generally larger craft lie, to right across the site upon which the pile is to be raised. Ships are often bunkered in the same way from the pile. They are all fitted with grabs, either manipulated by cable from a stationary winding engine or from one travelling on rails with the grab. The process is exceedingly simple. The grab is lowered into the vessel, automatically filled, raised, and conveyed along the bridge to the pile, where it is again lowered, gently opened and the coal deposited to swell the pile. The lever with which the Temperley crane is manipulated is a marvel of electrical skill, for which ever way you move the lever the grab responds and travels in the same direction; thus the mind, the hand, and the load all move together. All such installations belong to the first type mentioned, from which the coal is reclaimed as deposited, by the grab.

The "Dodge" conical stock-pile, so well known in the U.S.A., but

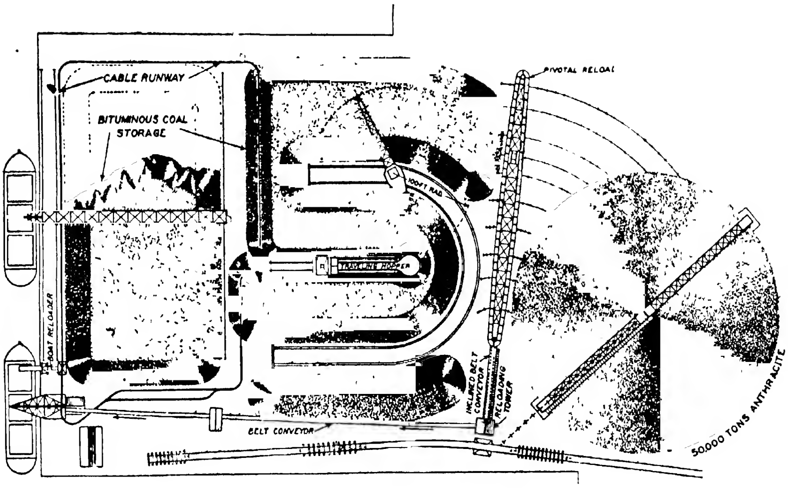


FIG 23—COAL STORAGE PLANT ON THE "DODGE" SYSTEM

which has not yet found favour in our land, is on different lines altogether from all those described above. Stock-piles on this system are almost exclusively used for storing anthracite coal, as bituminous coal cannot be stored in such high piles, which are frequently 60 ft. high and 200 ft. in diameter. There seems, however, no reason why such appliances should not answer equally well for storing other minerals.

The standard "Dodge" plant consists essentially of a push-plate or chain and flight conveyer supported by shear trusses, constituting a trimming machine which piles the coal with a minimum of breakage, delivering it upon the ground or at the ascending apex of a conical pile as it is formed.

The withdrawal or reclaiming of the coal is begun by an open-sided conveyer which is pivoted and runs on a number of circular ground-level tracks, extending between and over the area covered by the piles. This conveyer works against the edge of the pile, and follows up the receding edge as the coal is removed; it is operated by power and is so devised as to be fully under the control of one man.

In detail, the "Dodge" system, as usually applied to open-air storage on levelled ground, consists of two trimming machines, and the pivoted ground conveyer which travels radially between them, forming one group or unit. A coal storage plant consists of a number of these groups, which may be of equal or of varied capacities The shear trusses are fixed to correspond with the angle of repose to the coal, the front truss of each group, *i.e.*, the truss adjacent to the track-hopper or receiving point, containing the conveyer. This conveyer runs in a trough, having for a bottom a continuous steel ribbon about 12 in wide, which is wound upon a drum at the foot of the truss, and is paid out only as demanded by the formation of the pile, this feature provides a gentle discharge of the coal and prevents breakage.

Fig. 23 represents a "Dodge" coal-storing plant, showing on the right a typical "Dodge" pile. The middle and left-hand piles are of bituminous coal and, therefore, not so high. The installation is that of

the New York Edison Co., Shadyside, N.J. The coal may be delivered either by ship or rail. The anthracite is delivered to a standard "Dodge" trimmer, having a storage capacity of 50,000 tons. The bituminous coal delivered by the span of 200 ft. and commands a storage area with a capacity of 50,000. In addition, coal may be delivered on to a storage area at the back of the dock by cable car system and locomotive revolving crane, the radius of which is 100 ft.

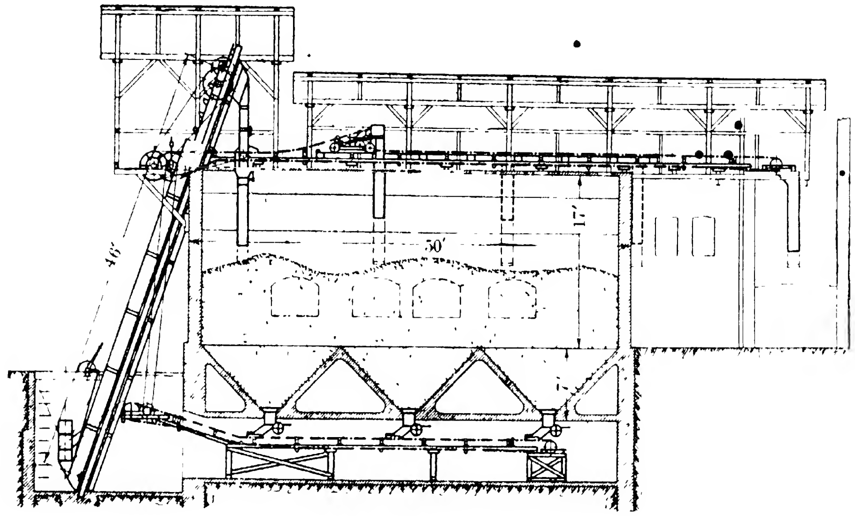


FIG. 24 COAL STORE EQUIPPED WITH BUCKET ELEVATOR AND TWO BAND CONVEYERS

vessels is raised by the tower or the bridge crane, which latter has a

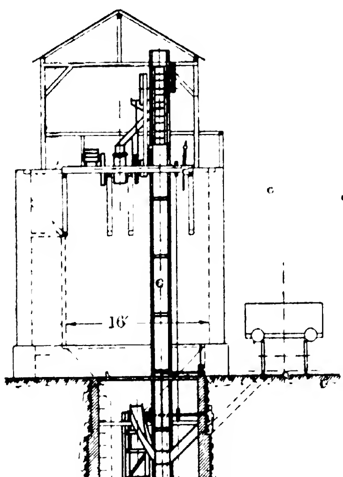


FIG. 25 —END VIEW OF FIG. 24

This store holds a total of 150,000 tons of coal. The anthracite is reclaimed as mentioned in the description of the "Dodge" system, and the other two piles of bituminous coal are reclaimed, as laid down, by grab.

Where coal must in any case be raised considerably to be accumu-

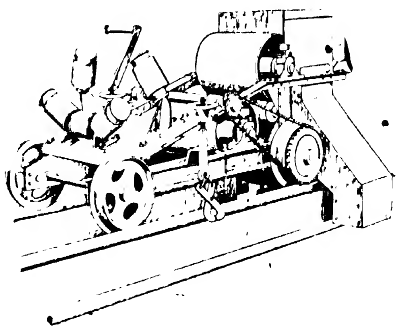


FIG. 26 THROW-OFF CARRIAGE OF THE UPPER BAND CONVEYER SHOWN IN FIG 24

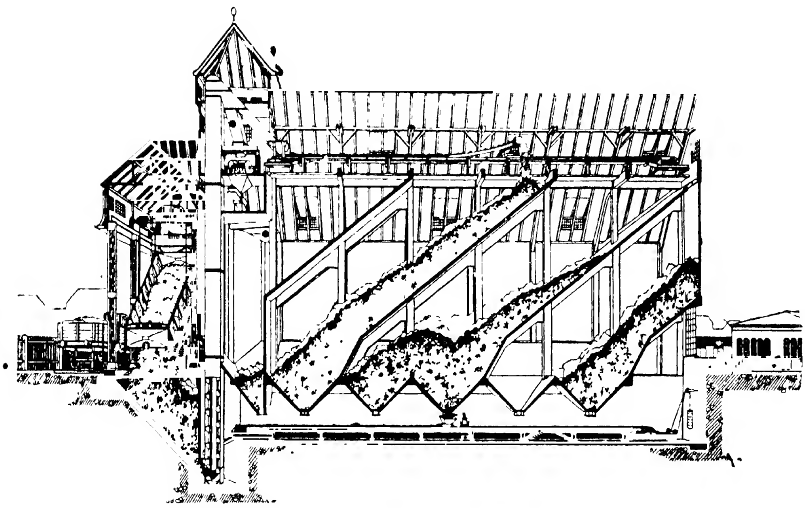


FIG. 27—COAL STORE WITH OBLIQUE FERRO-CONCRETE SILO DIVISIONS.

lated in a store, it often pays to elevate a little higher and erect a structure for the coal well above the ground and out of the damp, and this is also necessary if it should be desirable to protect the coal from the weather. When covered coal-stores or silos are used, they are in nearly every respect similar to the heaps, but in closed or roofed-in buildings, and what has been said concerning the feeding to and withdrawing from stock-heaps will, in some measure, also apply here. A mechanically equipped coal-store with bucket elevator and two band conveyers is shown in Figs. 24 and 25, and the throw-off carriage used on the band conveyer feeding the store in Fig. 26. The capacity of the installation is 50 tons per hour, and the band conveyers are 16 in. wide. For low initial expense, driving power, and cost of upkeep, such an arrangement has no equal. In all coal-stores, and especially enclosed ones, it is essential to reduce the drop of the coal when feeding the store as much as possible, firstly to save the coal from breakage, and secondly to avoid dust. A little care and judgment can generally prevent much of such damage by beginning to feed the pile or store at one end. When the store is quite empty there will be a high drop until a cone has been formed reaching to the feeding conveyers. From this stage onward the coal will not drop but roll down the cone of coal, the sides of which are formed at the natural angle of repose. Open spiral shoots are sometimes used, down which the coal can slide gently. Such a device is used in the locomotive coaling plant of the L. & N. W. Railway at Crewe. An ingenious plan to avoid practically all drop is that of the coal silos on Rank's system, a silo house with oblique ferro-concrete divisions, the slant of which closely approximates that of the angle of repose of the coal. Fig. 27 shows one of these, which needs no further explanation.

CONVEYERS AND ELEVATORS AND THEIR SUITABILITY FOR DIFFERENT DUTIES.

It has been stated in the introductory remarks that a description of the well-known types of

conveyers will not be given in these pages, owing to the fact that they have been so often described and that their general design has become familiar to most people. It will be more to the point to amplify such existing knowledge by summarising such devices and assigning to each type the purpose or purposes for which it is most advantageously used, and also to give the economic speed at which such devices should be run in order to give a fair capacity and ensure economy as far as wear and tear and consequent repairs are concerned, and to make them as immune from breakdown as possible. In perusing the following particulars, it may occur to some readers that some of the speeds and capacities are figured too low. This may be so, and most, if not all, of the machines could under pressure be run at higher speeds yielding proportionately higher capacities, but not with a desirable factor of safety.

Band Conveyer.—The best all-round conveyer; it takes less power to drive than any other. It is fitted with a composite belt of cotton and rubber for work under cover, and with a balata belt for work in the open. It is suitable for conveying all materials not sticky or hot, and particularly for grain, seeds, ore, coal, coke, sacks, etc. The speed of running varies from 120 ft. to 600 ft. per minute, according to the nature of the material being handled. It will work from a horizontal direction to an incline of 20°.

Continuous Trough or Pan Conveyer.—This type of conveyer is particularly suitable for small coal and coke, Thomas phosphate, cement clinkers, and ashes, if dry. Speed of running, 60 ft. to 120 ft. per minute. It will work from a horizontal direction to an incline of 10°, and if fitted with cross partitions up to 30°.

Worm or Archimedean Screw Conveyer.—This conveyer is inexpensive and reliable for short distances and small capacities of all small materials which are neither sticky, inclined to clog, of a very cutting nature, nor friable. It is particularly suitable for grain and seeds, either whole or in all stages of reduction in flour and oil mills, small coal (for short distances), fine cement, gypsum, Thomas phosphate, salt, and foundry sand. The speed is from 60 to 130 revs. per minute, and it can be used horizontally or at inclines not exceeding 30°.*

Gravity Bucket Conveyer.—One of the best conveyers, but it is not so frequently used in new installations as it used to be ten years ago, principally because less expensive conveyers are often chosen instead. It is particularly suitable for boiler-houses and for filling coal-stores. It should not be used for ashes on account of the corrosive effect of wet ashes on the bearing surfaces. The speed is from 30 ft. to 90 ft. per minute. As the buckets are suspended above their centre of gravity, and therefore always hang perpendicularly, the conveyer can work either horizontally or vertically, or partly in either direction.

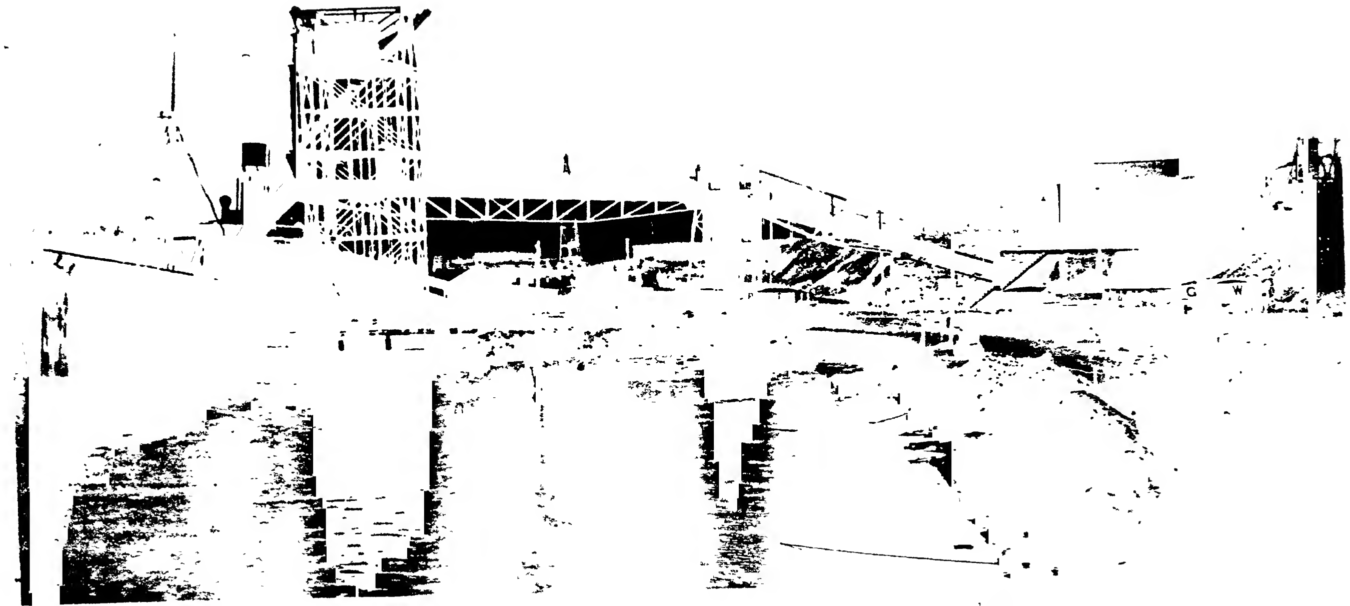
Push-Plate or Scraper Conveyer.—Is less expensive than a band conveyer and consumes more power, but is more economical in the latter respect at a low speed. Particularly useful for coal, foundry sand, and all such materials which are not of a cutting nature, or for fine powder of great specific gravity. Speed of travel, 60 ft. to 150 ft. per minute. It will work from a horizontal direction up to an incline of 30°, causing a reduction in capacity of 16 per cent. for every 10° of incline.

Wood Slat Conveyer.—This type of conveyer is more particularly for sacks, packing-cases, pig-iron, etc. The speed of travel is from 40 ft. to 60 ft. per minute, and it is best used horizontally or on an incline of not more than 10°.

Steel Plate Conveyer.—Particularly suitable for large coal which requires picking over. Speed of travel, 40 ft. to 60 ft. per minute, and it can be used up an incline not exceeding 15°.

Reciprocating Conveyer.—Used for feeding boiler-houses and coal-stores, for washed coal, copper ore, pyrites,

* If of a special type it can be made to work vertically like an elevator.



Coal loading out Plant at Port Talbot; capacity 700 tons per hour.
Erected by Messrs. SPENCER & CO., LTD., Melksham.

Thomas phosphate, coke. More particularly suitable for slightly sticky materials and those of a cutting nature on account of the small expense with which it can be repaired. The speed varies according to the type from 80 to 350 revolutions per minute

Push Trough Conveyer.—A stationary trough with reciprocating push-plates, used more particularly for salt, saltpetre and other chemicals, and foundry sand. The speed is from 50 to 60 revolutions or strokes per minute.

Hot Coke Conveyer.—Speed from 90 to 120 ft per minute. Will work from a horizontal direction to an incline of 30°, and by slightly altering the shape of the bars even up to 45°.

Elevator (Bucket)—Adaptable to all except sticky materials Particularly used for grain, coal, coke, sand, ice, ashes, salt, chemicals, slurry, etc.

	Feet per Minute
Speed for Flour, with closed elevator well ..	480 to 600
,, ,, Grain, ditto ..	360 to 480
,, ,, Nut Coal, ditto ..	120 to 180
,, ,, Salt, with closed elevator well ..	90 to 120
,, ,, Slurry, ditto ..	60 to 90
,, ,, Large Coal, fed by a shoot into buckets on the upgoing strand	60
,, ,, Coke, ditto ..	60
,, ,, Road Metal, ditto	50

All fast-running elevators (say, 180 ft. per minute and over) may be erected in a perpendicular position, whilst slow-running elevators (say, under 180 ft. per minute) must either be wholly or partly on an incline of from 60° to 75°, or the buckets will not empty themselves completely at the delivery point

Swing-tray and Finger-tray Elevators.—These are used for heavier individual loads, such as packing-cases, barrels, sacks, carcases in meat stores, and all goods on trays which require careful handling, such as ammunition in battleships, pastry, biscuits, small arm ammunition, and manufactured goods. They are used in ammunition works, bakeries and biscuit factories, warehouses, brick and tile works, chemical works, and for luggage in railway stations. The same machines can be used for travelling horizontally as well as vertically. Their speed of travel, if fed by hand, is from 20 ft. to 50 ft. per minute, and if fed automatically from 40 ft. to 60 ft.

Mono-rails.—Are used to convey material in bulk by skip or other receptacle, as well as for large individual loads, or for handling the receptacles for holding material in bulk Mono-rails are particularly used in foundries where rails on the ground for four-wheeled trucks are dangerous. Here the mono-rail is used for conveying the pans with liquid metal, see Fig. 28, and the same installation carries the receptacles for foundry sand and for the coarse sand from the drying room, also the foundry boxes and the rough castings fresh from the sand to the place where they are cleaned. They are also used in factories, general stores and warehouses, as well as for handling luggage at railway stations, in fact, everywhere where surface tracks have formerly been used

To get an approximate idea of the driving power consumed by the different types of conveyers, the following figures may be useful in the choice where several types of conveyers are equally suitable for the same purpose In each case the h p given is for a conveyer 100 ft long, with a capacity of 50 tons per hour

	Horse-power
Band Conveyer	4 to 5
Reciprocating Conveyer (Zimmer type)	8
Continuous Trough, Tray or Pan Conveyer	12 to 14
Push-plate or Scraper Conveyer	13 to 15
Steel Plate Conveyer.. ..	16 to 17
Wood Slat Conveyer . ..	16 to 17
Push Trough Conveyer ..	18
Worm or Archimedean Screw Conveyer	20 to 25

TELPHERS.

The narrow gauge surface track, with its rolling stock adapted to various

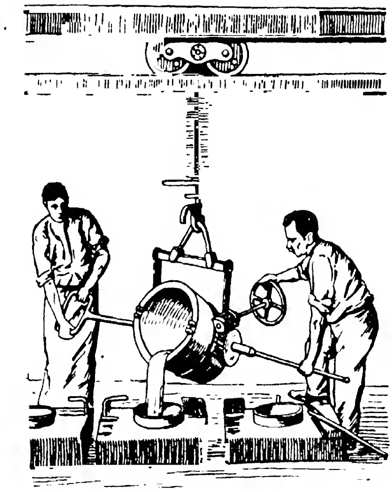


FIG. 28.—MONO-RAIL AS USED IN A FOUNDRY

uses, is a system now established to a lesser or greater extent in practically all industrial establishments of any importance for the purpose of connecting with rail or waterways, as well as for inter-departmental communication in such works. It is used to bring the raw material and fuel from store to plant, and again to transport goods in all stages of manufacture from department to department, and from shop to shop. It has apparently come to stay, while on the Continent, and more particularly in America, these surface tracks with their trucks have been largely superseded by the more scientific and more economical suspended vehicle supported from overhead rails, a system generally called mono-rails or telphers.

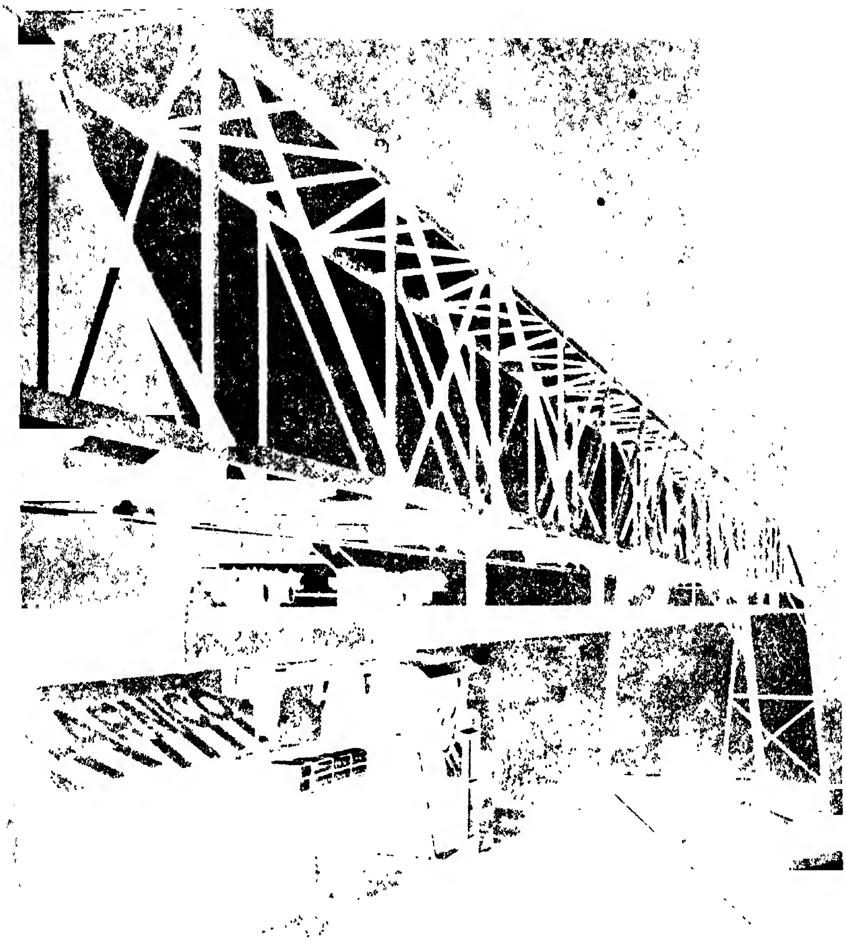
The gasworks and power-stations are, thanks to the not unselfish but still worthy enterprise of a few firms of engineers, the only noteworthy exceptions in this country in which the telpher has partly and sometimes wholly replaced the surface track with its manually, horse, and sometimes steam-propelled vehicles. The time has now come when a more radical and more universal change should be made, especially as it could take place gradually. The surface rails need not be disturbed until the overhead track is completed section by section.

The advent of electricity has been the chief factor in making such telphers possible, and perhaps nowhere has electricity—the handmaid of the engineer—assisted modern industry more than by its application to transport.

Some of the advantages of the elevated track on which receptacles are propelled by electricity, in addition to the saving of men, have already been mentioned in connection with the mono-rail. The track is extremely flexible, and may lead over buildings and across rivers.

In addition to the elevated track, the telpher consists of a suitable bogie or trolley on two to four wheels and supporting in a suspended position a well-balanced receptacle to carry the load. The bogie or trolley is fitted with, and propelled by, an electric motor, which takes its current by a small trolley pole from a single, double or triple conductor situated above or alongside the steel structure supporting the track.

The telpher installation may be what is called a "man-telpher," that is, one accompanied by an attendant, who from his cab starts, stops, lowers and dumps the load and returns for the next; or it may be so arranged that all movements are automatic, so that the telpher with its load when released at the loading point travels automatically to a predetermined point, dumps its load, and returns empty to be reloaded. Where the material to be handled is of such a nature that it requires putting on and taking off by hand, such as pig-iron and goods in cases, barrels, sacks, or carcases, or other large individual loads, the current is interrupted at the loading and unloading points, so that the telpher comes automatically to a standstill, and when loaded and ready to start it is given a slight push, when electrical contact will be re-established, and the telpher continues its journey, generally over an endless track, round and round, till the day's work is done.



Mono-rail Telpher Installation. Erected at the Confectionery Works of
Messrs Clarke, Nicholls & Coombs Ltd., London,
by Messrs. STRACHAN & HENSHAW LTD., Bristol.

Some of the man-telphers are provided with more than one motor and with electrical winches to pick up or lower loads from or to the ground at any point on the line, an arrangement which saves much labour in an engineer's yard or a fitting shop.

Automatic telphers have been perfected to an astonishing degree. They are provided with a perfect automatic block system, the passing telpher establishing its own electric connection, so that no second telpher can enter the line within a pre-determined distance of that in front, and if one is stopped for some cause or another, all the succeeding ones will stop at the same distances apart To give a full description of the intricate electrical fittings would be beyond the scope of this article, but to watch their uncanny movements one comes to the conclusion that they do all but think

Telphers for large and bulky loads are fitted with a trailer, or double telphers are used, either direct connected or geared; the latter is generally the case where an excessive gradient has to be negotiated. The speed of travel varies from four to a maximum of twenty miles per hour, according to the nature of the load, the capacity required, and the gradient of the track.

The track may be bracketed to the sides of buildings, or supported on the open land on A-brackets of timber or steel structural work. The load can be switched on to branch lines over track switches, which the telpher man himself operates from his cab. The telpher man can also reverse his machine at will, open and close doors, run the entire length of the storehouse or shop, and pick up loads without any previous preparation. In and out handling from the works is equally well performed by the same telpher, and there is no limit to distance.

Telphers have been more particularly applied, as has been mentioned, to gas and electricity undertakings for the purpose of handling the large quantities of coal and coke which have to be continuously dealt with in such works, and they are employed in nearly all the largest gas and electricity works in this country, but the example has not been followed by many of the smaller establishments. These appliances seem to be particularly applicable where the duty is heavy and continuous, and where the route to be traversed is anything but a straight line, and also where branch runs have to be made off the main road.

These telpher machines are usually designed to travel on a single rail, which is generally bolted to the top flange of rolled steel girders of suitable depth and flange width, according to the span between the available supports. There may be as many curves and branch turnouts as are necessary, the design of the machines being such that any reasonable curve may be negotiated with ease and safety.

Fig. 29 shows a two-way telpher track switch of Robert Dempster & Sons, Ltd, in plan and elevation This two-way automatic blocking and locking switch may be operated either from the floor or driver's cabin It will be observed that the track is blocked where the switch is open, whereby all danger of over-running on the open track is obviated

Fig. 30 shows a four-way telpher track switch in plan and elevation, of the same firm This four-way monorail track, coupled with an automatic locking and blocking switch, is operated by the hand-rope indicated from the floor level, its special advantage being that immediately the switch is disconnected from any section of the track (to join up any other section), it automatically blocks all disconnected sections, which completely obviates the danger of over-running an open section.

Most telphers are driven by electric motors, and Fig 31 shows a two-motor telpher with trailing carriage, built by Robert Dempster & Sons, Ltd. This machine is specially built with small wheel base and fitted with trailer, which readily lends itself for negotiating sharp curves and for lifting long skips. In the end view the method of mounting this telpher upon a rail-track carried by steel trestles is shown, as well as

the method of attaching the live wires along the track and the collecting gear.

A petrol or oil motor telpher also built by the same firm is shown in Fig. 32. The petrol or oil motor and tanks are mounted on the telpher frame, whilst the hoisting and travelling motions are operated through clutches and machine-cut spur gear on an intermediate shaft, which latter is coupled direct to the oil motor by a silent chain drive. The machine is mounted upon a self-sustaining double track and has, therefore, four wheels which give the necessary rigidity for the successful working of the telpher.

Telphers have been built for dealing with loads up to four tons, but there is no reason why heavier loads should not be dealt with if the necessity arises. The lifting speeds range from 60 ft. per minute with heavy loads to 200 ft. per minute with light loads and a long lift. The travelling speeds may be anything from 500 to 1,000 ft. per

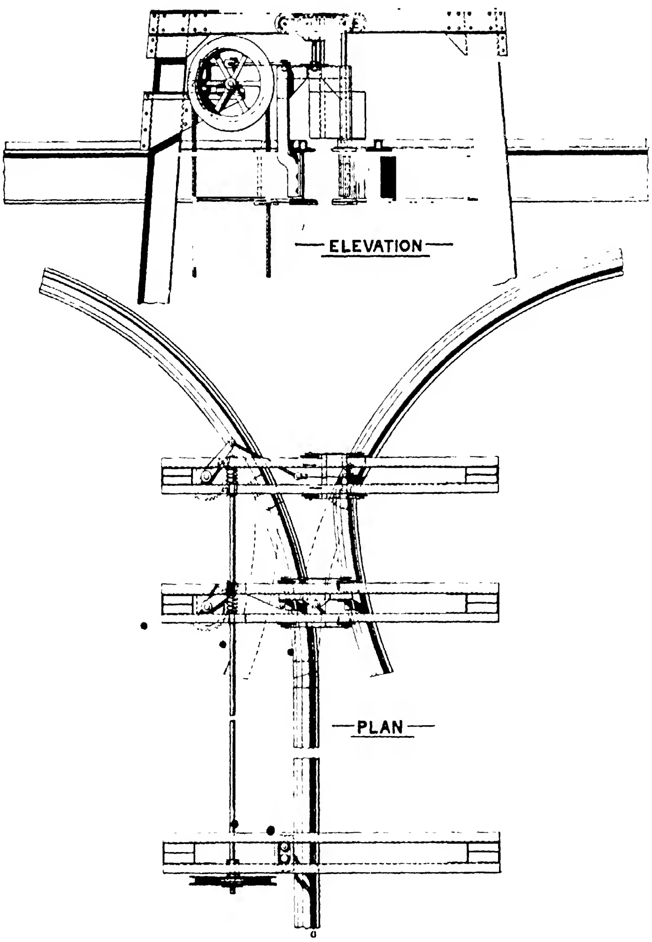


FIG 29 —TWO-WAY TELPHER TRACK SWITCH

minute, according to the nature and length of the run.

TERMINAL PLANT.

Mechanical terminal facilities make all the difference in the cost of transport by rail and waterway, for if hand-labour only is available the cost of handling at the terminals, *i.e.*, getting material in bulk it falls to the lot of the recipient to handle his own goods. In the former case, *i.e.*, the railway, sidings are generally extended to the works of the consumers, and at the termini of these they provide their own plant to unload and get the material into store. In the case of the waterway it is more difficult, as the river

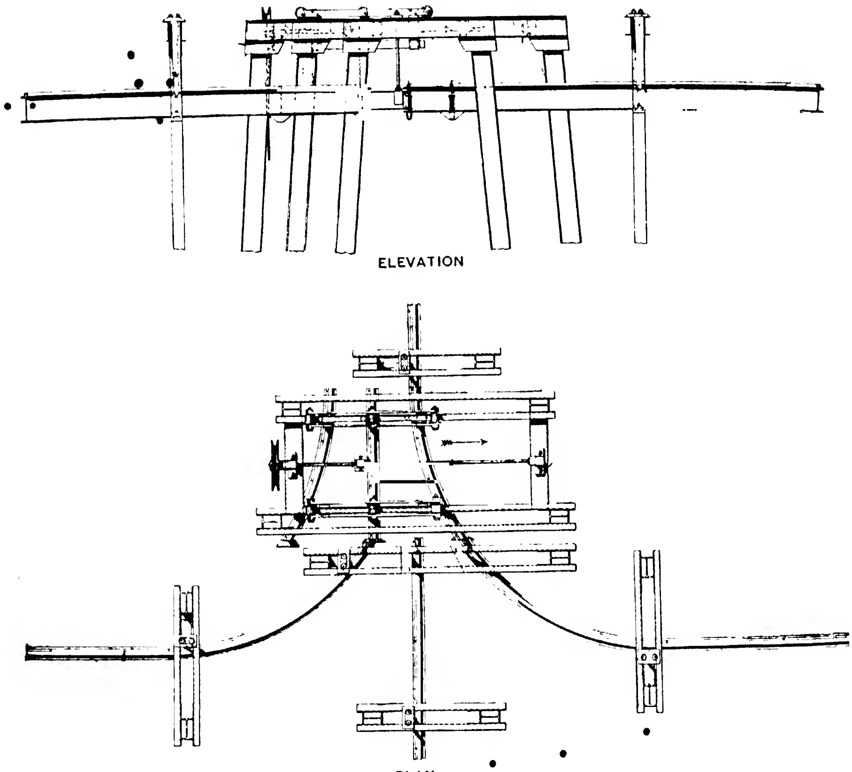


FIG. 30.—FOUR-WAY TELPHER TRACK SWITCH

the goods on at one end and off at the other end, might under certain circumstances be higher than the actual transport on such rail or waterway. The transference from one carrier to another should, therefore, be the serious concern of railway and steamboat companies. Facilities are often provided when dealing with merchandise in cases, barrels or sacks, but for or canal frontage is not always sufficiently large to accommodate private plant, and even if it is, it generally necessitates a siding, ropeway, telpher, or some other kind of conveyer to take the material to the factory or works in the hinterland. Terminal plant on a waterway must often have provision to cope with the variation of the tide, and invariably requires the material

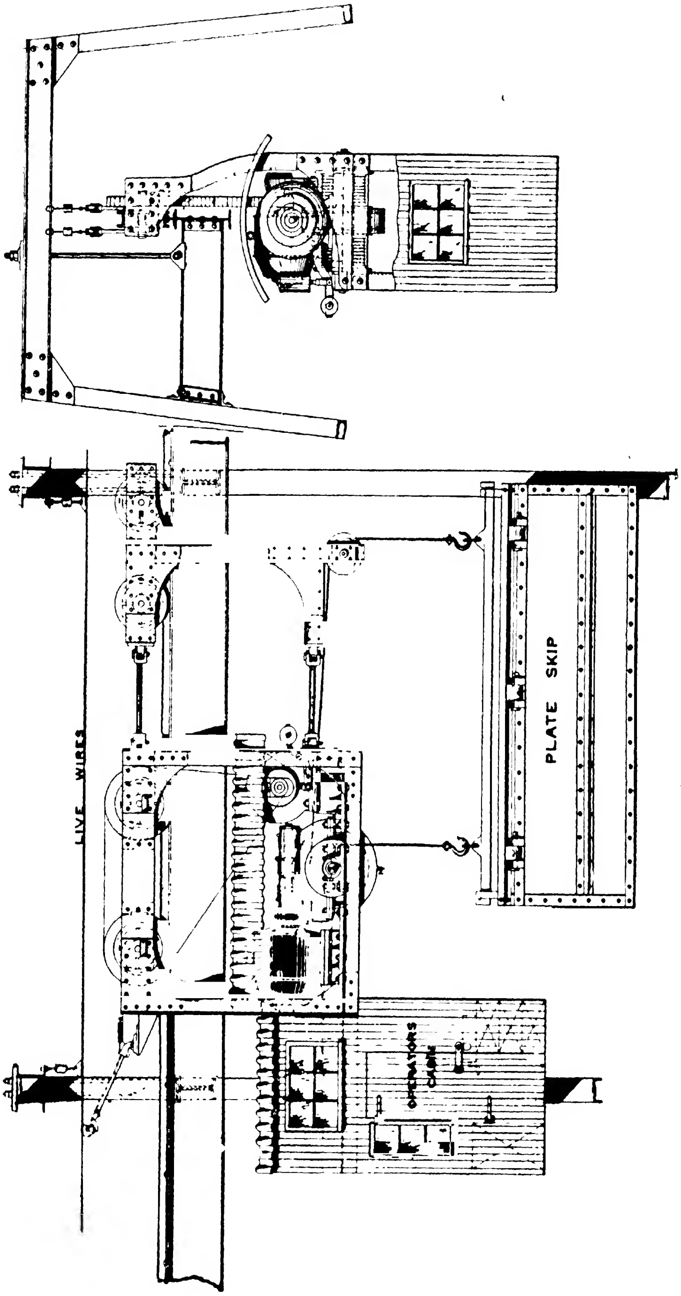


FIG 31 —TWO-MOTOR MONO-RAIL TELPHER

to be lifted out of the craft, while in the case of the railway siding the material is dropped in the first instance out of the truck either by hand and shovel, by tipping the truck (as shown in Figs. 33 and 34), or by employing self-emptying trucks which discharge chinery does not only save many hands and is cheaper, but it also saves a great deal in demurrage on railway trucks and vessels, and it is not too much to say that on this account only the boat or railway truck can be used to do twice the work it used to do

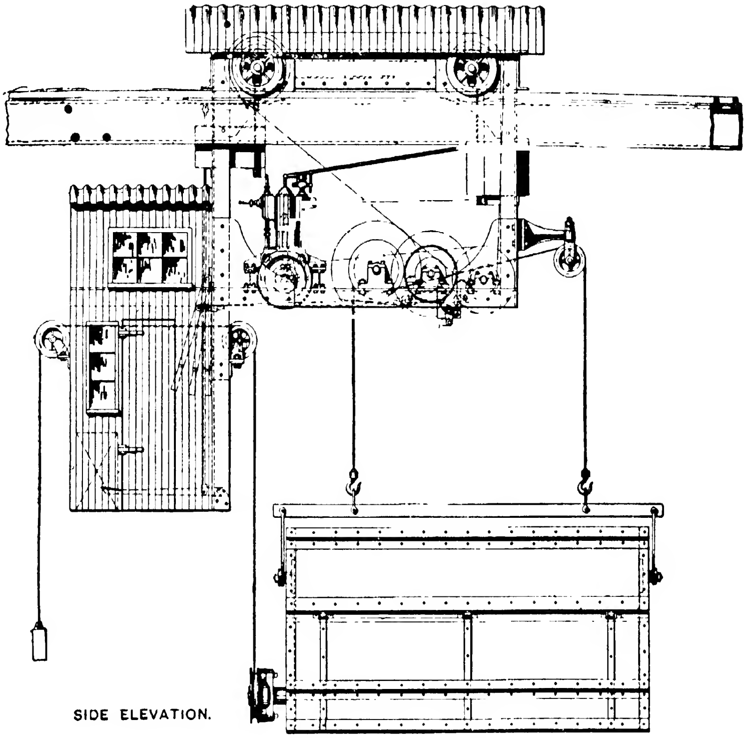


FIG. 32.—PETROL OR OIL-MOTOR TELPHER

their load automatically when the bottom doors are opened (see Figs 35 and 36).

In both cases we may consider that it costs but little more to convey the goods a few hundred feet, or even yards, than to convey them, say, fifty feet, when once held in suspension in or by conveying machinery, as long as it is done without rehandling, except it can be accomplished automatically, as, say, from an elevator to a conveyer or from one conveyer to another

The expeditious unloading by machinery when unloading by hand was the only terminal facility, not to mention the smaller cost of the less extensive landing piers and platforms upon which the goods used to be heaped for rehandling by human machines The interest on a judicious capital outlay for such machinery and depreciation charges will often be less than 1d. per ton handled.

It has been said in the beginning that the appliances dealt with in these pages will not include very extensive plant, yet it is interesting to know

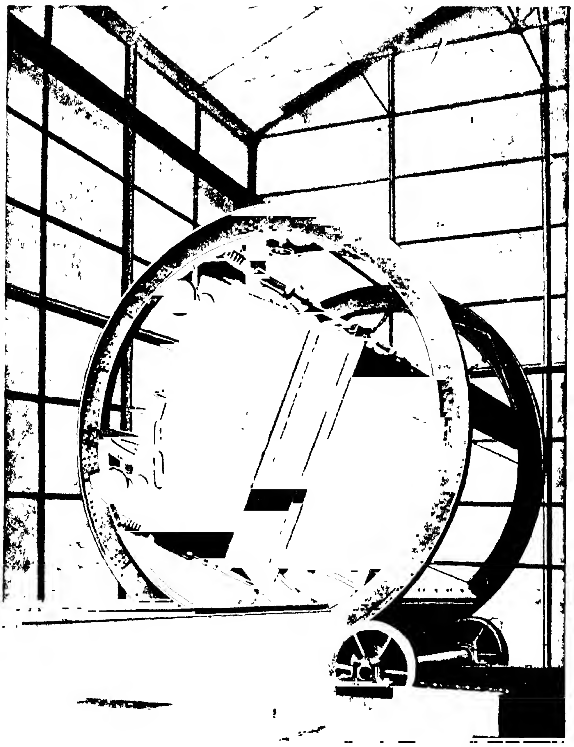


FIG 33 —BABCOCK & WILCOX ELECTRIC TIPPLER FOR STANDARD RAILWAY WAGONS

that some of the terminal plant on the Great American Lakes can handle coal and ore at an inclusive cost of $1\frac{1}{2}$d per ton, which formerly, with an army of men with wheelbarrows, cost 1s. 6d. per ton. A 10,000-ton steamer can now be unloaded there by four Hulett unloaders in 5 to 6 hours, and an equipment at one wharf in Philadelphia of two 36 in band conveyers can deliver 28,000 bushels of grain into ship per hour.

We are here more particularly concerned with the unloading appliances at the end of the carriers' journey, as there is not so much to say for the loading end Coal, which is, after all, the most important of the bulk goods handled, is dropped into railway trucks at the colliery from screening or picking machinery, which is always at such a height as to require only a slight drop or slide of the coal into the trucks, and ore is dealt with in a like manner. With the loading for waterways coal tips are generally used for this, which are installed at all our coal ports to such an extent and with such a worthy enterprise that they need no advocate In fact, if all branches of industry were supplied with plant for the mechanical handling of material as the coal-shipping trade, there would be no need for this propaganda in the national interest. With these loading facilities the cargo coal is shot into the ship's hold by raising the whole coal truck bodily to a sufficient height by tips or hoists that it empties itself down a shoot.

But there is another method which is worth mentioning, though the cir-

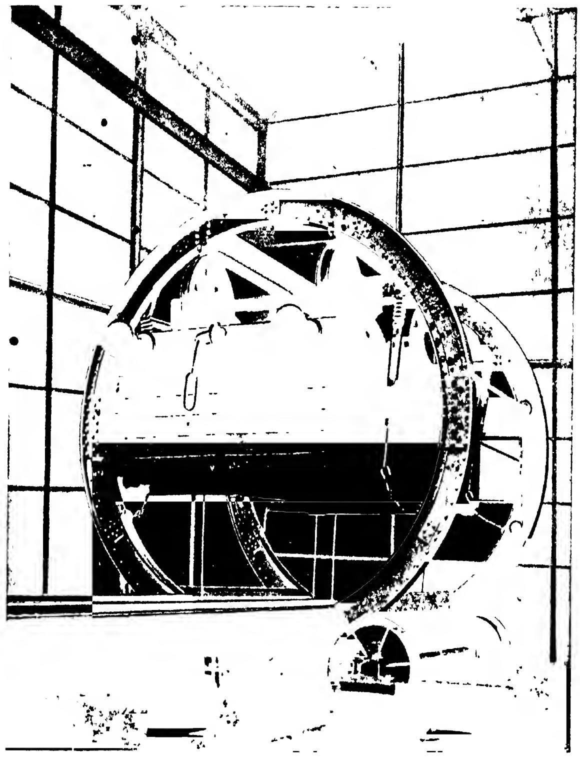


FIG. 34.—ANOTHER VIEW OF BABCOCK AND WILCOX TIPPLER

cumstances are not often in favour of its installation, and that is the loading of ships or barges from elevated bunkers so that it can be let out by gravity, no mechanical devices being necessary, but what is necessary and not often available is high ground in close proximity to the waterway, so that trains of hopper wagons can let their coal out into the overhead bunkers and from there into the vessels. As the state of the tide and the size of the vessels vary, and as coal cannot be dropped any distance without diminishing its value, some provision has been made by providing some bunkers, which terminate high up, and others lower down. Other devices consist of lowering shoots of a variety of types, one of which is shown in Fig. 37, an installation of the Link-Belt Co. on the pier of the Virginia Railroad Co. at Sewall's Point, Virginia, where 62 such adjustable coaling shoots are employed. The distinctive feature of this shoot is the vertically sliding hopper A with its telescopic shoots permitting such adjustment as may be required for variations of the tide and height of vessel, and preventing breakage by securing a slow continuous flow from the hopper to discharge shoot. The delivery is controlled by a regulating gate.

A terminal station which receives the material in bulk on a railway siding may sometimes consist of a mono-rail or telpher (according to the size of the establishment), the receptacles of which are on the same level as the truck bottom and which run parallel for some ten yards or so with

the trucks, so that such goods as pig-iron may be transferred by hand. One man can load 40 mono-rail cars per hour, or, say, ¾-ton. Telphers are larger and one would carry such a load or more At the foundry or factory the pigs are again removed by hand and stacked. A terminal arrangement of this description is only for such heavy loads as pig-iron, but, of course, it can be used, though not very economically, for coke and sand. By far the most usual terminal arrangement for coal, ore or grain, is a hopper-bottomed pit or track-hopper between the rails, or often one extending somewhat beyond the sides of the rails, into which the coal is shovelled in the old-fashioned way, involving an additional expense of from 3d. to 5d. per ton. If automatic hopper wagons are available, the bulk goods are simply run out into the pit; or, thirdly, the contents of the truck are emptied by a hydraulic ram or electrically-driven winch, which lifts up one end of the truck by the axle, and on the door at the further end being opened the material runs out into the pit (see Fig. 38). The top of the pit is generally covered with a grating of flat iron bars standing upright, so that very large lumps cannot fall through, and these are helped through by a tap with a hammer. This precaution is taken to prevent the elevator which receives the material from the hopper being choked by such large pieces. The mesh of the grating depends upon the size of the buckets of the elevator, and these in turn depend upon the capacity of the whole plant. If, for instance, the capacity is small, an elevator might be chosen which will take half-an-hour or

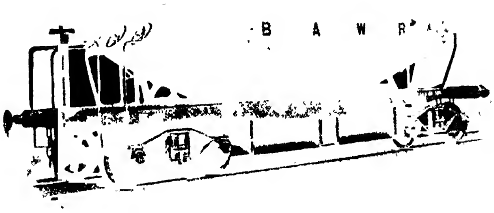


FIG 35 —TYPE OF SIDE AND CENTRE DISCHARGE HOPPER WAGON OF THE LEEDS FORGE CO, LTD

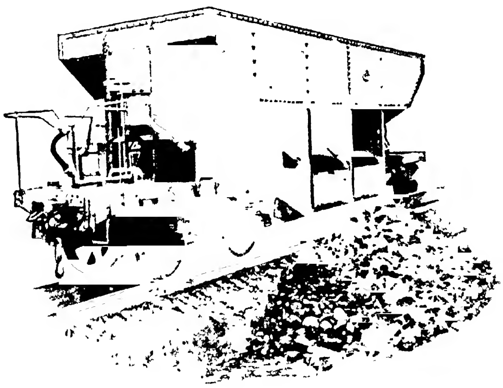


FIG 36 —HOPPER WAGON WITH SIDE DISCHARGE OF THE LEEDS FORGE CO., LTD

more gradually to handle the ten tons which have been dumped into the receiving pit If the plant is larger, a truck might be emptied every five minutes, in which case the elevator has to have a capacity of 10 tons in 5 minutes, or 60 tons an hour, and such an elevator can naturally take much larger lumps. Where crushing rolls are used before the coal enters the elevator, gratings over the pit are superfluous. The elevator then lifts the material sufficiently high to feed it into a conveyer of some kind situated at a higher level than the bunker, stock-heap, or other destination of the material. The length of this conveyer and, therefore, the choice of the most suitable type, depends upon the distance of the terminal plant from the spot where unloading is to take place. The conveyer may be erected on a slight upward gradient if delivery high up is required.

Terminal plant for the waterside consists of a receiving tower with stationary winch, the simplest form being the mast and gaff rig, or of a transporter, cantilever or bridge crane, in conjunction with a travelling grab, or of a telpher and grab, or it may consist of what is generally termed a "barge elevator," *i.e.*, a bucket elevator which is lowered into the vessel, when it acts like all other elevators and lifts the material to its upper terminal, where it is delivered into some kind of continuous or intermittent conveyer and sent to its destination, as with the terminal plant for railway sidings.

The employment of a light steel structure from which a man-telpher is suspended, is probably in most cases the ideal solution. The line can be so laid that it overhangs the ship, when the man from his cab lowers the grab for its load, raises it, and follows the track of the rails, which may lead to a variety of positions by means of switches, so that the material can be dumped on a stock-pile, or taken into the boiler-house or some other auxiliary coal store. When the terminal plant is not in use for unloading, the same installation can be used for replenishing the bunkers from the stock-heap, as well as to convey manufactured goods back to the ship.

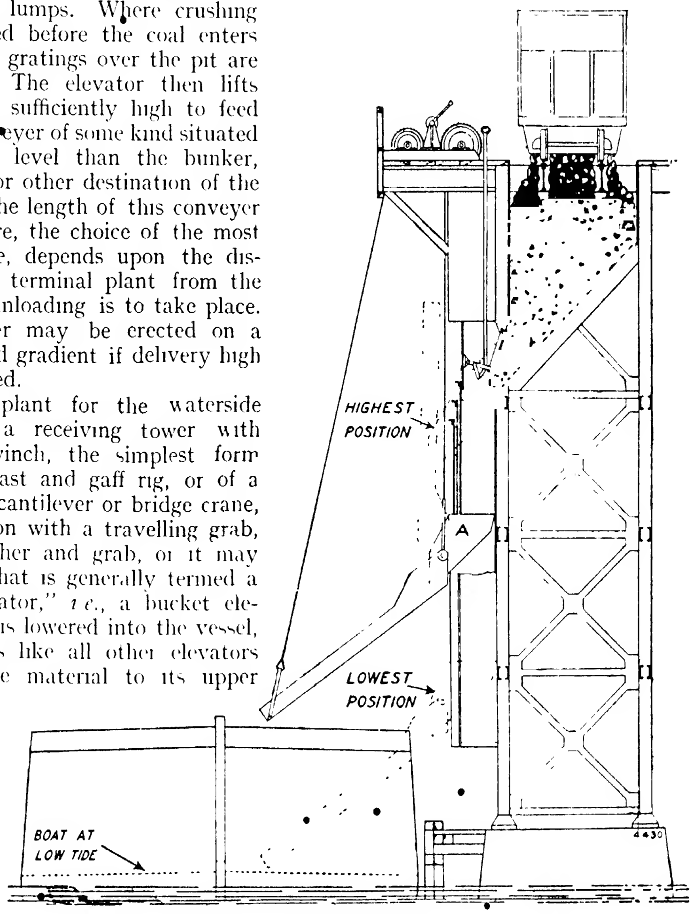


FIG. 37 —TELESCOPIC LOADING SHOOT FOR COAL

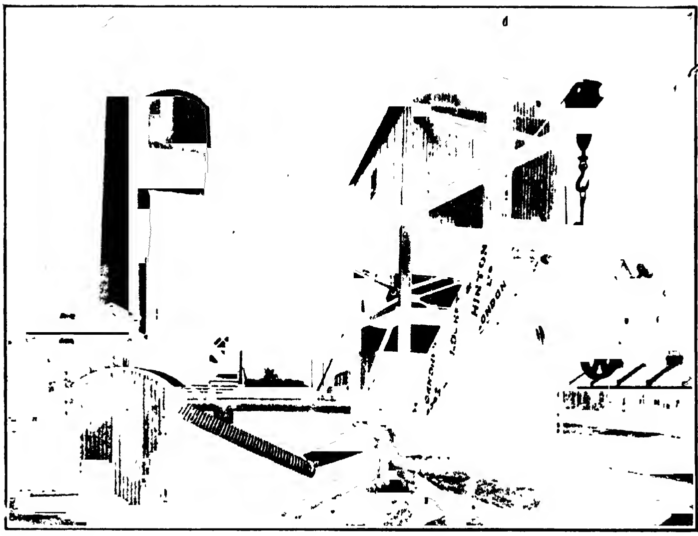


FIG 38 —WAGON TIP AT THE NORTH METROPOLITAN ELECTRIC POWER SUPPLY CO.'S WORKS, WILLESDEN, BUILT BY BABCOCK & WILCOX, LTD

Fig 39 shows a Temperley transporter for unloading coal ships into a store on the quay side This plant is here illustrated more as an example of a waterside terminal installation, though it furnishes a fine example of a coal-store, somewhat different from those previously described, being enclosed by substantial retaining walls The plant is the property of Messrs. Fraser & White, at Portsmouth, the largest firm of coal shippers and merchants on the south coast The capacity of the store is 15,000 tons when filled to a surcharge of 6 ft The enclosing walls are of reinforced concrete on the Kahn system, and of the cantilever buttress type The space so enclosed is 240 ft long by about 95 ft wide. The rail-track for the two transporters is on the two longer walls. The span of the rail-track is about 93 ft., and the overhanging portion is 88 ft. The grab holds $1\frac{1}{4}$ tons, and the maximum duty is 65 tons per hour for each transporter. The speed of hoisting the full grab is 240 ft. per minute, and that of transporting it 900 ft. per minute, while the grab makes 40 to 50 trips per hour. Each transporter is manipulated by four electric motors, the one for hoisting is of 65 h.p., that for transporting 30 h.p, the one for moving the transporter bodily 15 h p., while that for lifting the beam is of 10 h.p. This installation was fully described in *Engineering* of July 2nd, 1915.

It is well to erect such waterside terminal plant for a capacity of not less than 75 to 100 tons per hour in order to make it a commercial success, and for smaller demands run the installation less frequently. For smaller duty, say 50 tons per hour and under, a locomotive crane with a grab is more economical Concerning barge elevators, they are often attached to the factory building if it is close to the waterside. Such an elevator has already been described, and is illustrated in Fig 20. The subject having already been dealt with, it will suffice to mention here that the advantage of barge elevators over grabs is that they are continuous working instead of intermittent, and that if trimmers are necessary in the barge, their occupation is less dangerous when feeding barge elevators than when trimming the coal for grabs

THE MECHANICAL EQUIPMENT OF BOILER-HOUSES.

The deletion of the wheelbarrow as a factor in boiler-house economies, together with the abolition of the antiquated methods associated with its use, have been followed by the introduction of well-designed coal and ash handling apparatus in many of the leading boiler-houses The results obtained by the new plant have more than justified the optimism which led to the innovation, not only in the saving of labour and the consequent reduction of fuel costs, but in the improved cleanliness and comfort thereby induced

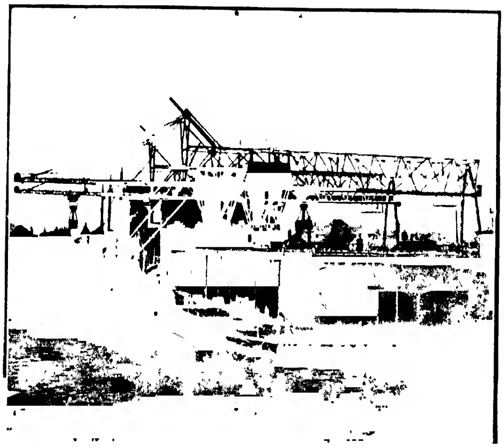


FIG 39 —TEMPERLEY TRANSPORTER FOR UNLOADING COAL SHIPS

The cost of running suitable conveyers in boiler-houses, including interest on capital expenditure, attendance, oil, motive power, depreciation and repairs, should work out at a fraction of a penny per ton. It has been estimated that in conveying and elevating coal at the rate of 40 tons per hour to a height of 40 ft., 10 hours per day, with a judicious expenditure of £1,000 for the plant, the cost of handling coal should not exceed one-halfpenny per ton, allowing for interest on capital expenditure, attendance, etc

The general construction of the conveyers should be as simple and as durable as practicable. They should run preferably at a slow speed to prolong the life and reduce maintenance expenses They should admit of the interchangeability of their parts, some of which should be kept in stock for immediate repairs, and it should be possible to vary their capacity in order to suit the requirements which may obtain at any time, and, above all, they should be as immune as possible from breakdown

In boiler-houses all labour-saving additions will help on the country's cause, from the small single elevator for feeding one or two boilers to the large and complex plant of gravity bucket, belt, and chain conveyers, destined to save the work of hundreds of men The economy of a boiler-house depends firstly upon the mechanical methods by which the coal is brought to the boilers and the ashes taken away from the boilers; and, secondly, upon the mechanical stokers which feed the boiler furnaces with coal.

A great deal has already been said concerning the mechanical equipment for getting coal into boiler-houses and particularly into overhead bunkers, and also concerning the treatment of

ashes, so that we need only show and describe a few typical installations to give a complete picture of what a modern boiler-house should be like. In doing so we must include the bunkers in order that the equipment may be complete, but before doing so we will summarise the best methods of handling coal and ashes under a few abnormal conditions.

When it is required to install coal-handling equipment in an existing boiler-house where roof trusses are too low to admit of the installation of coal bunkers over a range of boilers, we recommend one or two larger bunkers at one end, or in the middle of the building, with a "larry" or a travelling hopper on overhead rails, to haul the coal to the boilers. This appliance is usually motor driven and can be arranged to measure or weigh the coal. The advantages of this system over separate shoots from bunkers to the stokers are, firstly, that the coal from the main bunker can be taken to any one boiler, while in the other case only the coal in the bunker over or opposite each boiler is available for it; secondly, it weighs and records all coal burnt, and, thirdly, it is less expensive.

When handling ashes, it may be that a tunnel or basement is impossible or impracticable (a tunnel being necessary for a suction or car and skip system), in which case a push-plate or a drag conveyer in conjunction with a bucket elevator is recommended. Such plant will handle up to 20 tons per hour, and will require only 3 h.p. for every 100 ft. of length, the first cost and repairs are low, the shallow trenches for their reception are simple and accessible, and as the plant can be run continuously, at a slow speed, it requires a minimum of labour.

Coal bunkers vary very much in shape, size, the material from which they are made, and the position in which they are placed. We will only consider those suspended above the boilers, as those placed lower down cannot be recommended as the most economical. In some of the earlier bunkers the leading idea was to make them as large as possible, and so dispense with a separate main stock outside the boiler-house, but such elevated bunkers of large dimensions necessitate very strong foundations, and therefore make the whole of the boiler-house structure more expensive. We will therefore eliminate them here and deal only with such bunkers holding about a week's supply. As to shape, square hopper-bottomed bunkers are used, sometimes only one or two

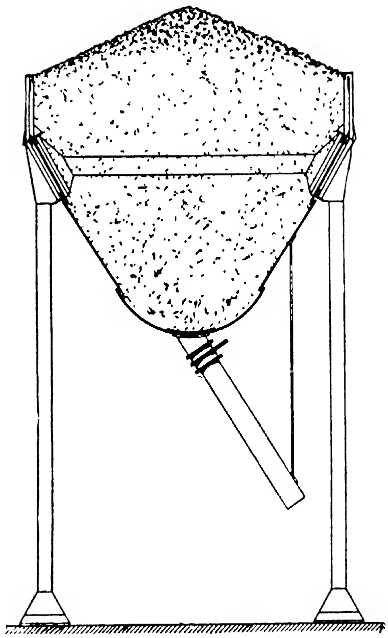
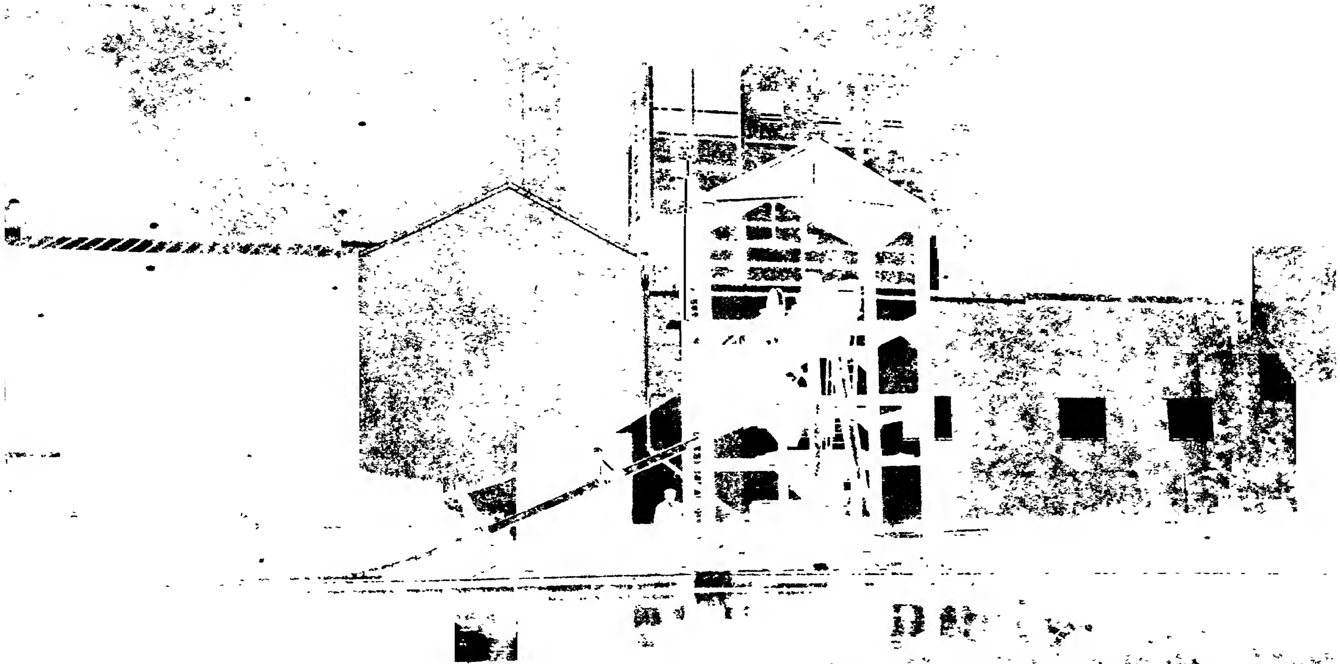


FIG. 40.—SUSPENDED COAL BUNKER

for supplying a range of boilers (by a "larry" or conveyer), or more often in an unbroken series with one hopper-bottomed outlet over each boiler. In the first instance the bunker or bunkers are located close to the receiving elevator and a conveyer just below the outlet may distribute the coal. In the latter case the conveyer from the elevator runs along the top of the bunkers, depositing its load into them. Such square bunkers have sometimes been made of timber, but now are nearly always of steel. Sometimes large cylin-



Coal Conveyor and Ash Shoot at Coventry Corporation Electricity Works.
Erected by Messrs. ED BENNIS & CO., LTD. Little Hulton.

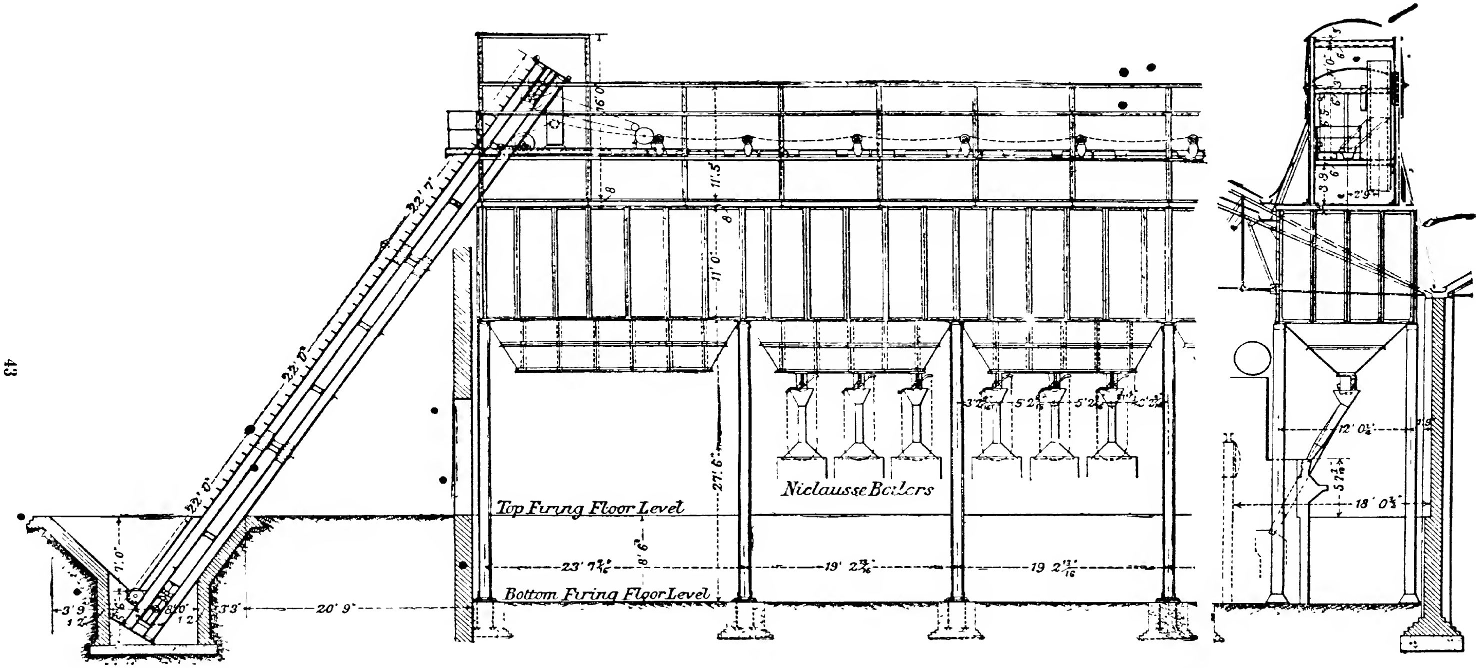


FIG 41 —SECTION THROUGH BOILER HOUSE INSTALLATION AT THE ELECTRICITY STATION, SOUTHEND-ON-SEA

drical bunkers with conical hoppered bottoms are used as main bunkers, distributing the coal like those just described over a range of boilers by a conveyer, or for a double range of boilers the same is carried out in duplicate. The most usual form of bunkers in a modern boiler-house is a continuous V-shaped trough, the lower end being rounded more like the letter U (see Fig. 40). The bunkers may have partitions in them, and they all have outlets with slides to correspond with each boiler. They are generally called "Self-cleaning suspension bunkers," and are likely to be universally used in the future. The construction is simple From two main supporting girders steel straps are suspended at close and regular intervals, and they are covered inside with steel plates, so that the straps support the full weight of the bunker and its contents. As the wear by corrosion is somewhat high, they have been either concrete lined or wholly made of ferro-concrete. The latter are all but indestructible, but the reinforcement must be of large section

The boiler-house of the Electricity Station at Southend-on-Sea* is shown in Fig. 41. The elevator and the U-link conveyer shown in the illustration have already been illustrated to a larger scale in Figs. 18 and 19. The mechanical equipment is by Ed. Bennis & Co, Ltd. The storage capacity of the bunkers is 500 tons The coal is brought in carts and dumped into the receiving hopper, which is below the ground level. The elevator is fed from this hopper by gravity through a Bennis rotary safety feeder, which ensures a regular supply to the elevator buckets and prevents any undue rush which might choke and jam the elevator. The elevator is 70 ft. long, has a capacity of 20 tons per hour, and is driven by an electric motor. The U-link conveyer which feeds the bunkers takes the coal from the elevator, and extends the whole length of the boiler-house, about 106 ft. The bunkers are carried on twelve stanchions of steel joists 27 ft. long, resting on concrete foundations.

The Metropolitan Electric Supply Company have a fine installation, a general view of which is shown in Fig. 42 and a plan in Fig. 43. The installation is built to handle 60 to 80 tons of small coal per hour from the railway truck to the boiler-house. The terminal plant consists of two tipplers which revolve the railway truck bodily, so that its contents fall into the large hopper, from whence it passes by a U-link conveyer 38 ft. long up an incline to the main elevator 106 ft. long, which is also of the U-link pattern, the incline being 30° and the rise above the ground 40 ft. The advantages of these revolving tipplers over the end tip are that the truck empties more completely and without assistance by hand, and also that trucks without hinged end doors can be used. At its upper terminal the main elevator delivers into a third U-link conveyer running the full length of the boiler-house, about 400 ft., feeding the overhead bunkers. The conveyers are all 15 ins. wide by 8 ins. deep, the U-links are of 2¼ ins. by ½ in. flats, and have a pitch of 12 ins. They are secured at the joints by ⅞ in. rivets and washers. The material used for the links is Siemens-Martin acid steel of a tensile strength of from 28 to 32 tons per square inch, with an elongation of 20 per cent in 8 ins. The trough is of cast iron ½ in. thick at the sides and ⅝ in. at the base. The boilers are all fitted with Bennis automatic coking stokers, and one man can comfortably look after six of the stokers. The expenditure of driving power is 25 h p. from the receiving hopper to the bunkers.

Following upon these two fine examples of boiler-houses at home, the writer has been permitted by the R. H. Beaumont Co., of Philadelphia, to illustrate a number of installations executed by them, showing the great variety of the applications to which

* Fully described in *Engineering*, October 30, 1914.

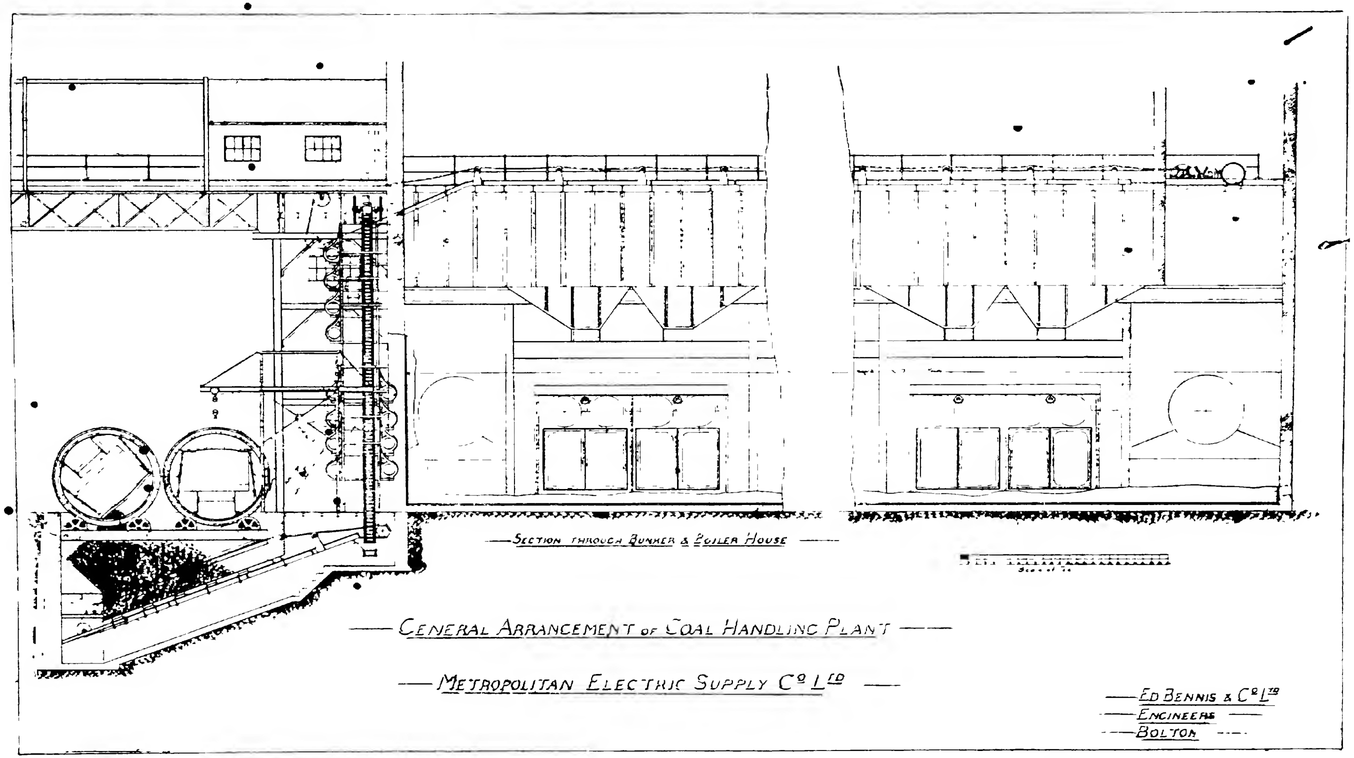


FIG 42 — ELEVATION OF BOILER-HOUSE OF THE METROPOLITAN ELECTRIC SUPPLY CO, ACTON LANE, LONDON

the different appliances have been employed in the United States.

A coal store adjacent to a boiler-house of the U.S. Naval Medical School Hospital at Washington is illustrated in Fig. 44. A V-bucket elevator does duty here as a conveyer in its horizontal path in the higher regions of the store. The very same plant will suit a range of bunkers over boilers equally well

The Northern Indiana Gas and Electric Co., East Chicago, Ind, employ the same type of V-bucket elevator and a push-plate conveyer at right angles to it to feed the bunkers over two ranges of boilers (see Fig. 45). The coal is received by railway trucks, discharged into a track hopper, and thence into the elevator well. The ashes are collected by tip car and lifted to the ash bunker by skip hoist. The ash bunker is so placed that the empty coal trucks can receive the ashes.

The Ludlow Manufacturing Associates, Ludlow, Mass, employ push-plate or flight conveyers for the combined purpose of conveying and elevating the coal, while the ashes are handled by the pneumatic suction system see Fig. 46.

A very interesting plant is that of the New York and Pennsylvania Paper Co, Willsboro', N.Y. (Fig. 47). It shows how the undulations of the ground can be turned into account, in using the hillside as an automatically self-emptying coal store, the only expense being a substantial retaining wall.

It is instructive to see in Fig 48 how an apparent mistake in the original layout of a power plant can be rectified. The plant is that of the A. M. Collins Manufacturing Co, Philadelphia. The coal has here to be taken from the railway siding across the factory building to the coal store and boiler-house in the rear. Being a comparatively small plant, the coal is handled by three 12 in. worm conveyers. The one in the boiler-house is shown in end view. An ordinary bucket elevator located between the mill and the boiler-house lifts the coal from the first to the second worm conveyer.

Another difficult proposition is shown in Fig. 49, the boiler-house, of the Baldwin Locomotive Works, Philadelphia. The illustration shows the solution of the difficulty of handling the coal by telpher. The boiler room is on the ground floor of a four-storey shop, and lack of head room prevented the adoption of overhead bunkers. The coal is delivered from railway trucks *via* a coal breaker and band conveyer into a pit with a 100-ton capacity. The grab manipulated by the telpher takes the coal from this pit and feeds the stokers, the latter having a high front so that sufficient coal for 24 hours run may be piled on each stoker. The ashes are again here disposed of by the tip car and skip hoist, the latter manipulated by a pneumatic cylinder and plunger.

Two plants in which both coal and ashes are handled entirely by locomotive crane and grab are shown in Figs. 50 and 51.

A boiler-house installation with an independent steel structure carrying an ash bunker fed by tip car and skip hoist is shown in Fig. 52.

The economy of small elevators for feeding the hoppers of machine stokers with coal, and acting independently, is now fully recognised by those who have made a careful study of the ways and means of reducing boiler-house costs The needs of small boiler-houses and the possibilities of effecting economies by means of small elevators, in conjunction with well-designed stokers, has been overlooked until recently, yet Great Britain's industries are made up of thousands of small works, mills, factories, etc., owned by small capitalists, to whom the study of economy in their own boiler-houses is all-important. If we show each proprietor how to make 1 lb. of coal do the work of two, how to get the coal from the barge or the truck to the boiler furnace at a quarter of the cost now incurred, and convince him that instead of paying for manual labour to remove

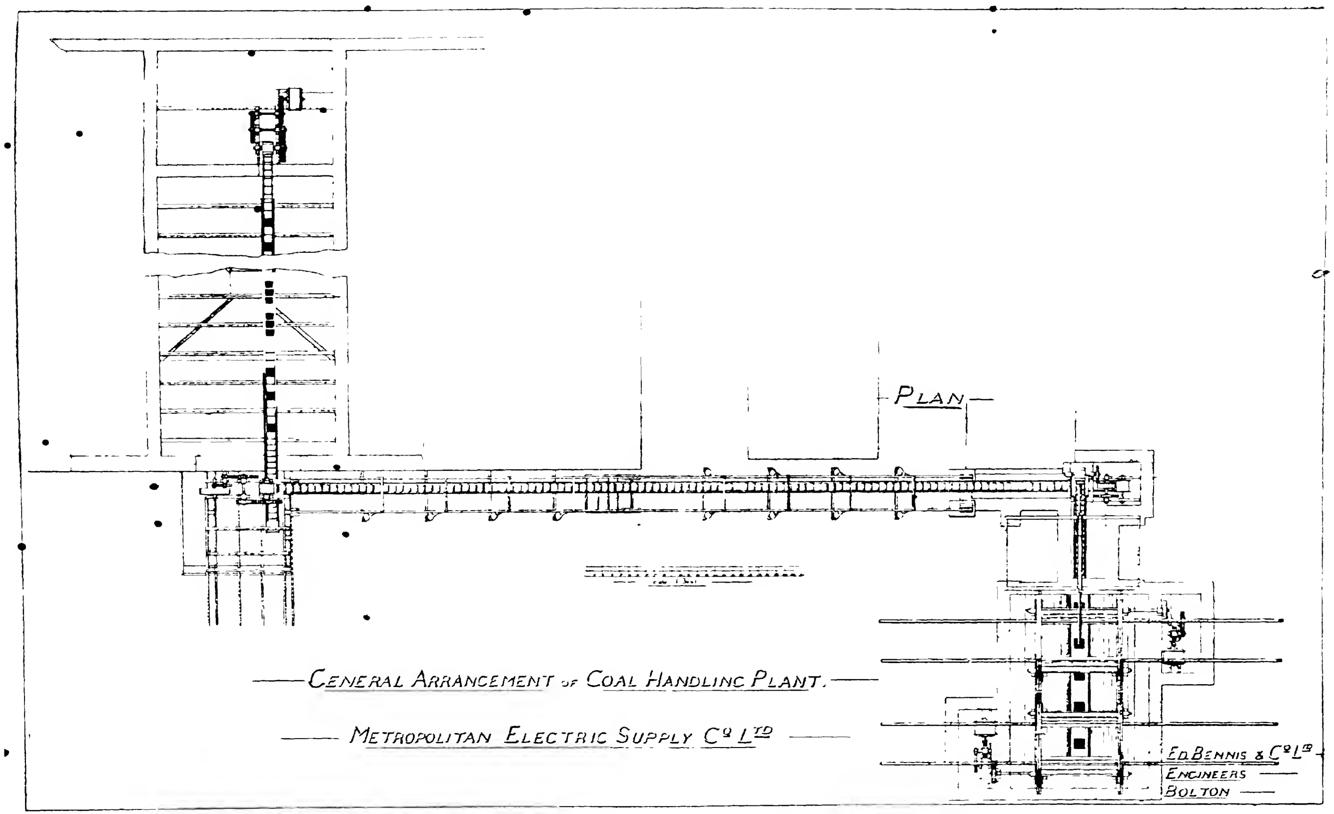


FIG 43.—PLAN OF FIG 42, SHOWING THE CONVEYERS

the ashes from the furnace, he can automatically remove them at practically no cost at all, he should not be slow to avail himself of the advantage offered by the manufacturer of labour-saving machinery who has, maybe, spent a lifetime in the study of such problems. Where boiler-houses are

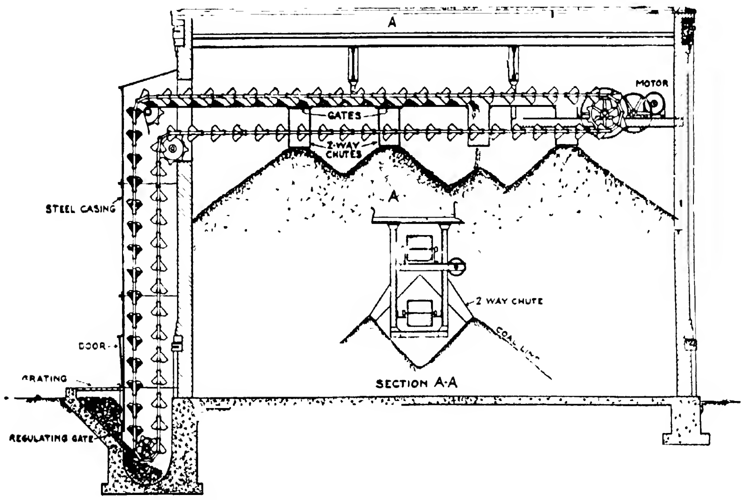


FIG 44 —COAL STORE ADJACENT TO BOILER-HOUSE OF THE U S NAVAL MEDICAL SCHOOL HOSPITAL, WASHINGTON

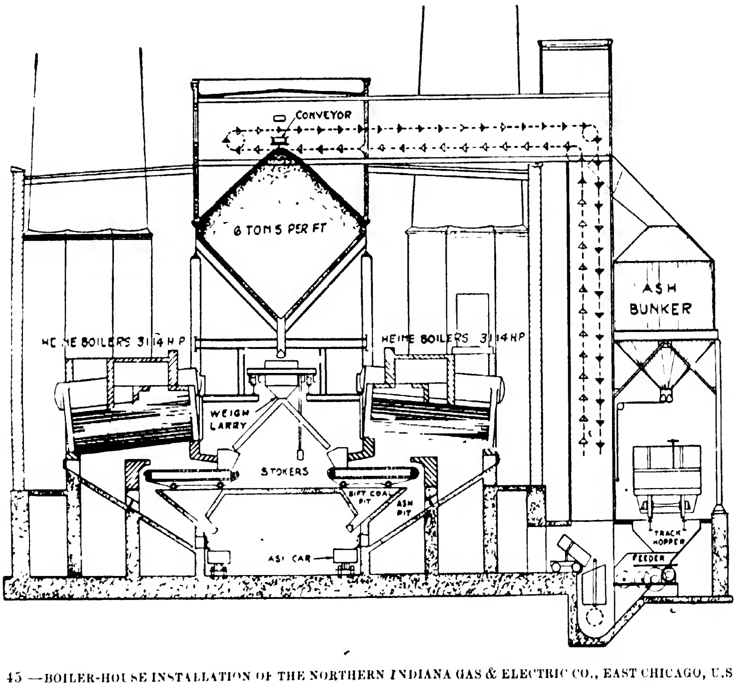


FIG 45 —BOILER-HOUSE INSTALLATION OF THE NORTHERN INDIANA GAS & ELECTRIC CO., EAST CHICAGO, U.S A

small, or by reason of their arrangement an elevating and conveying plant cannot conveniently be put down, the employment of small elevators is strongly advocated. One elevator to each boiler, or one to every two boilers, may be desirable. Fig. 53 shows such an installation by Ed. Bennis & Co., Ltd., where each boiler with its stokers is fed from a separate small elevator. One such elevator can be installed for about £60, which can effect a saving of £30 per annum, or 50 per cent. on the outlay. Fig. 54 shows an elevator on the same idea in front and side elevation. A few concrete instances will serve to point the assertion. The first to which attention may be directed is that of an elevator to feed a single boiler in a boiler-house at St. Paul's Mill, Hoddlesden, near Darwen, in Lancashire. The available space was too restricted to permit of any coal storage. Previous to the erection of the elevator, and while the hand firing system was in vogue, the mills were much pressed for steam. During the winter months it required the help of an additional fireman to ensure a sufficient supply of steam, and this in

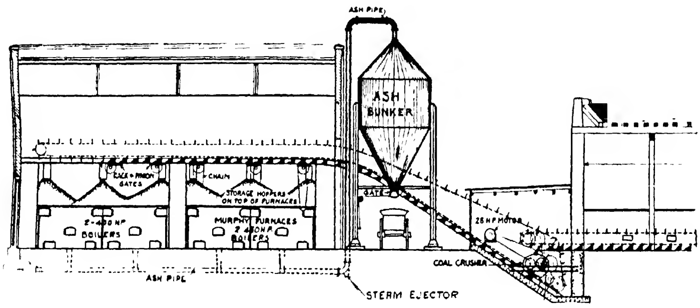


FIG. 46.—BOILER-HOUSE INSTALLATION OF THE LUDLOW MFG. ASSOCIATES, LUDLOW, MASS., U.S.A.

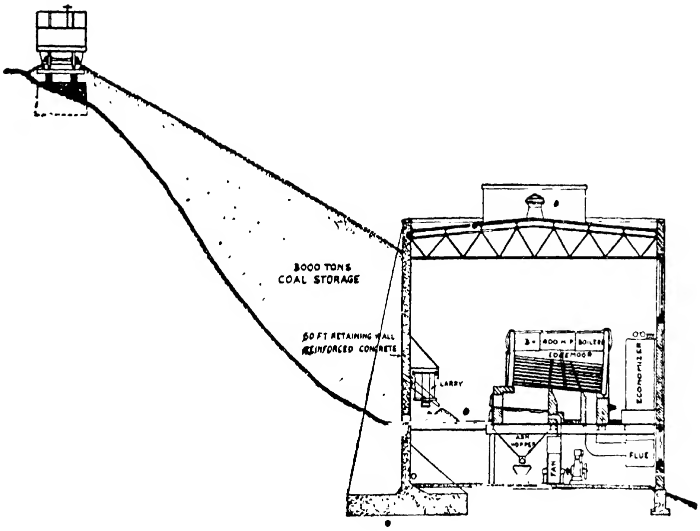


FIG. 47.—BOILER-HOUSE INSTALLATION OF THE NEW YORK AND PENNSYLVANIA PAPER CO., WELLSBORO, N.Y.

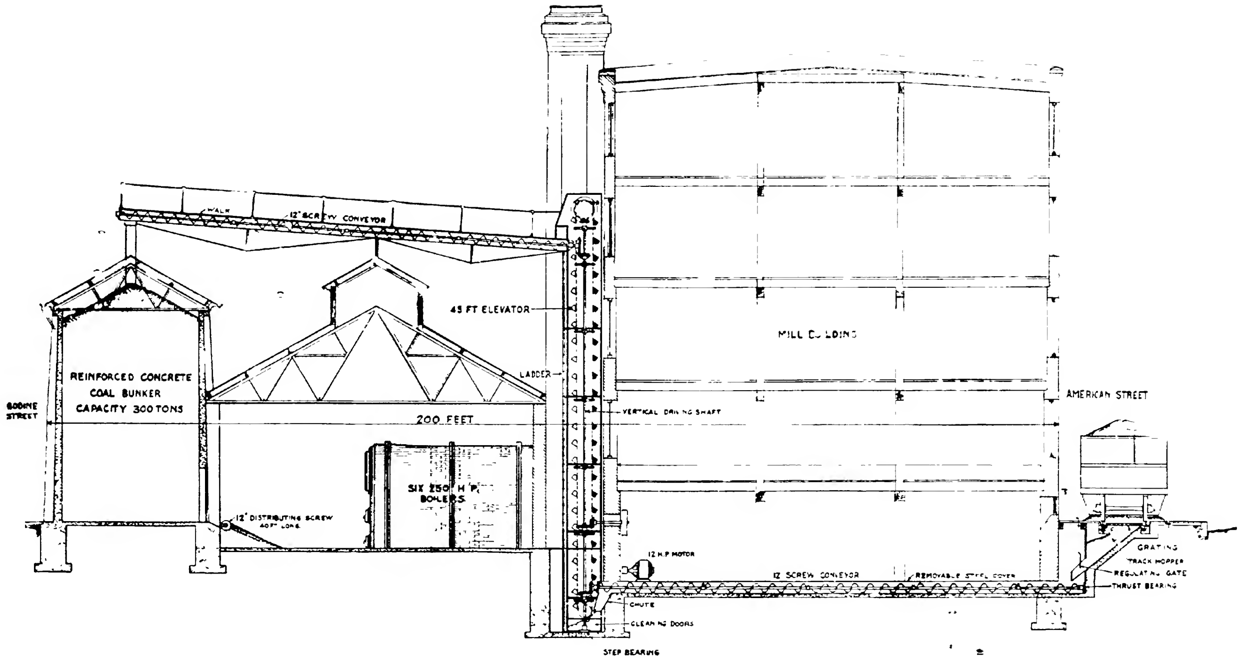


FIG 48 —BOILER-HOUSE INSTALLATION OF THE A M COLLINS MFG CO, PHILADELPHIA

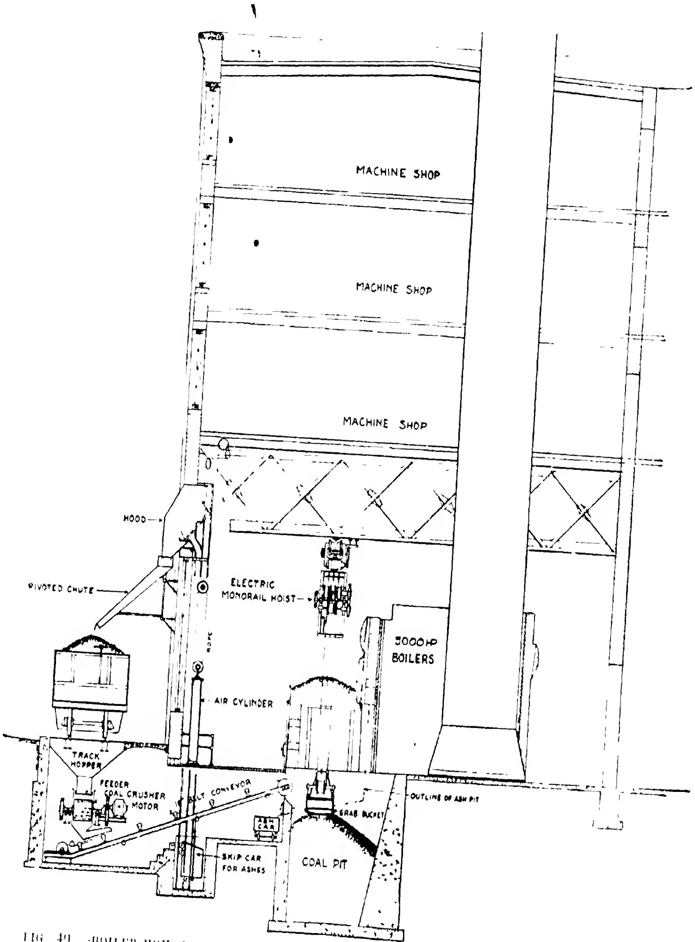


FIG. 49.—BOILER-HOUSE INSTALLATION OF THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

spite of the fact that one tapping machine was connected to a boiler some distance away. The immediate effect of firing by elevator and machine stoker was to run the extra tapping machine easily and materially to increase and sustain the load on the boiler without increasing the coal bill. Prior to the erection of the elevator no coal storage in the boiler-house was possible. The installation of the elevator has, however, made it possible to store two or three loads of coal in the boiler-house, at the same time keeping it wholesomely clean. The elevator is capable of lifting 2 tons per hour, and by its use the boiler plant is rendered almost automatic, with the consequent saving of labour costs.

A second elevator of a similar type erected in another textile mill in the same locality supplies two boilers by means of shoots branching off to the four hoppers, which they feed at an even rate and in the quantities required by the furnaces.

A third elevator feeds the coal to the

stokers of three boilers. By means of a cut-off door the supply can be regulated from the full capacity of the elevator to a few pounds.

In larger installations conveyers are necessary, as we have seen, to distribute the coal from a main elevator over a range of boilers. All chain types of conveyers are used for this, and especially the U-link type. Its economy may be gauged from the following In the City Road Station of the County of London Electric Light Co, which generates many million units per annum, by the old wheelbarrow system of unloading the cost to deliver the coal from the barge to the boiler-house floor was 1s per ton and if it had been carried to the bunker room it probably would have been 2s. Since the laying down of the elevating and conveying plant the cost is easily covered by 5d. per ton, including delivery into the bunkers and

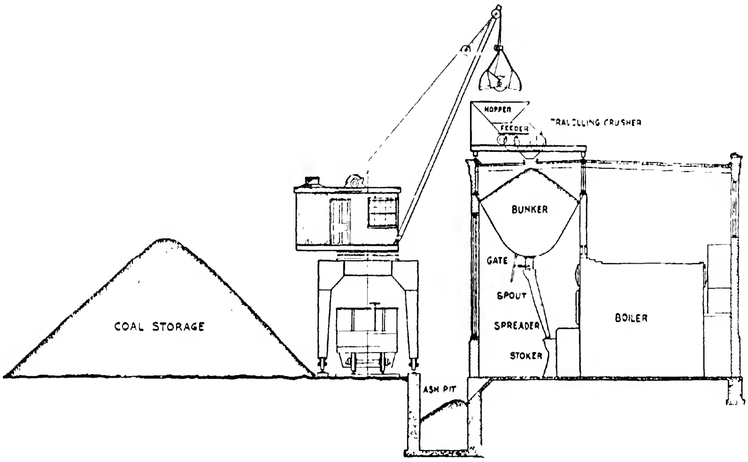


FIG 50 —APPLICATION OF LOCOMOTIVE CRANE TO THE HANDLING OF COAL AND ASHES

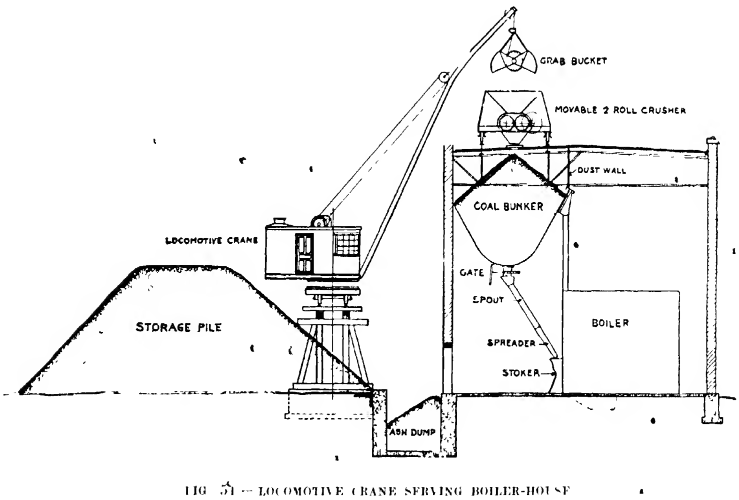


FIG 51 — LOCOMOTIVE CRANE SERVING BOILER-HOUSE

the additional cost of water supplied from the hydraulic power mains used by the crane for unloading the coal. One man attends the hydraulic crane, does all the work to the conveyer plant, greases the bearings, and otherwise looks after the entire apparatus, and is never uncomfortably pushed The seven coal bunkers, which form part of the equipment have a total capacity of over 1,000 tons Each conveyer—there are several—can be run independently, or all may run together

Perhaps it will be as well to mention while dealing with boiler-houses that the pneumatic handling of ashes does not, as a rule, pan out economically unless the installation is for about 2,000 h.p. and over. Any of the other systems which have been described will do for smaller plants.

Of the continuous conveyers, the U-link is the best, but for such a duty its life is but short The trough, though of the hardest cast iron and $\frac{5}{8}$ in thick, will wear through, if constantly in use for 24 hours per day, in two or three years, and as the trough is made in lengths of 10 ft, one or two such lengths can be replaced at a time. The chain will last about four years before it has to be scrapped It has been mentioned earlier that ashes can be removed by grab. This method is only recommended where a grab is used for handling coal at the same boiler-house. The ashes may then be caused to collect by gravity or short conveyers into one or more underground pits, from where the grab can remove them at intervals (see Figs 50 and 51).

Mr. Clarence Coapes Brinley, in a

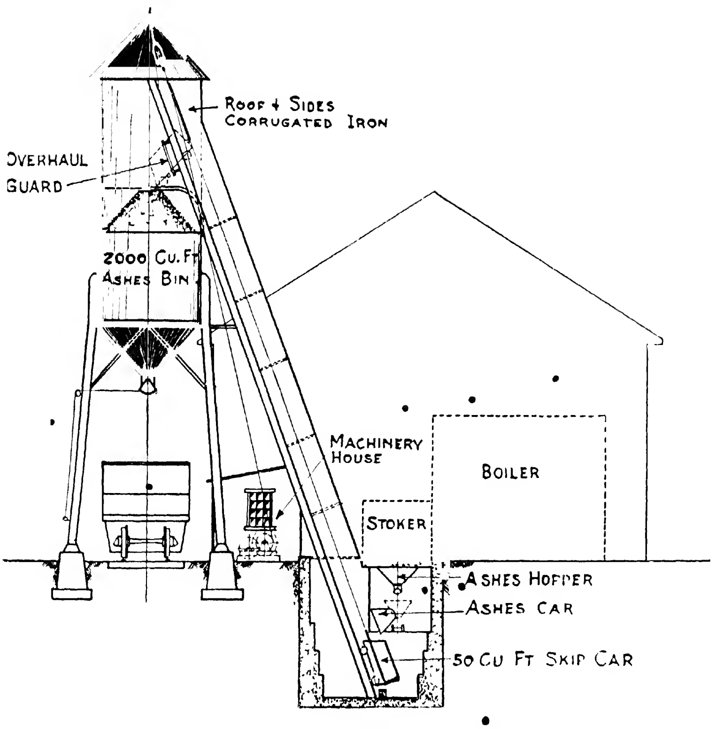


FIG 52—SKIP HOIST AND ASH BUNKER FOR BOILER HOUSE

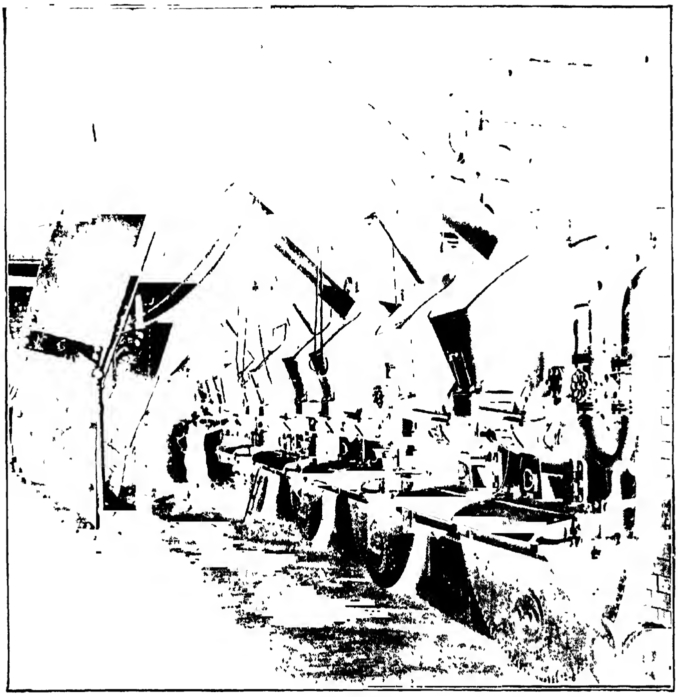


FIG. 53 A SERIES OF ELEVATORS EACH FEEDING THE AUTOMATIC STOKERS OF ONE BOILER

most interesting and instructive article in *The Engineering Magazine* of September, 1915, gives figures of the actual saving in labour in certain power houses after the modern equipment had been installed, and as it is by no means easy to obtain such information, we give as follows an abstract of what he says.

The power plant of Riverside and Dan River Cotton Mills at Danville, Virginia, has recently been entirely remodelled. Originally nine men were employed to haul the coal to the boiler room, and twenty-six men to fire the boilers and remove the ashes. This meant the expenditure of $59.00 per day for labour. Since remodelling, the plant is being run by ten men at a cost of $17.00 for labour per day, a saving of $42.00 (over £8) per day.

The plant of the H. F. Watson Company at Erie, Pennsylvania, shows similar results. This plant of 2,300 h.p. unequipped required twenty-eight men to operate for a 24-hour run, while the same plant, but increased to 3,100 h.p. and completely equipped with handling machinery, is now attended by five men, three on the day shift and two at night.

But the value of mechanical handling equipment is not to be measured by the saving in wages only. The question before the steam producer to-day is whether his plant is more economical, more reliable, and easier to manage, when attended by a large force of poorly paid, unskilled, and unreliable coal-heavers, or by a small number of intelligent, well-paid, skilled workmen, operating an equipment which is the result of years of engineering experience.

The following comparison will give the reader a reasonably clear idea of

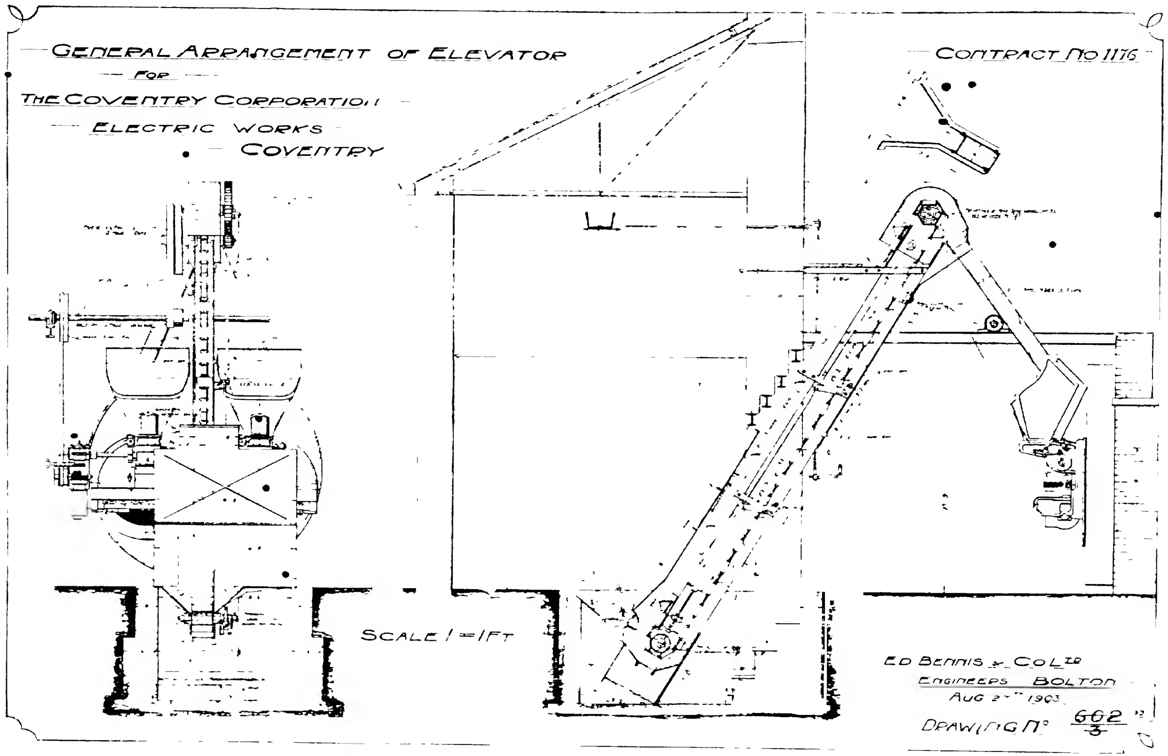


FIG. 54.—FRONT AND SIDE ELEVATION OF ONE OF THE ELEVATORS SHOWN IN FIG. 53.

the relative cost of the various types of conveyer suitable for boiler-houses. The proposition is in each case for handling 50 tons of coal per hour 50 ft. vertically and 100 ft. horizontally.

The gravity bucket conveyer, including track hopper, feeder and supports, would cost about £1,530, and would require 15 h.p. to drive.

A bucket elevator and band conveyer would cost about £900, and would require 10 h.p.

And the combination of a bucket elevator and a push-plate conveyer would cost about £700, and require also, say, 10 h.p. to drive.

A feeder would, of course, not be necessary except for the gravity bucket scheme, and any of the systems could be operated by one man.

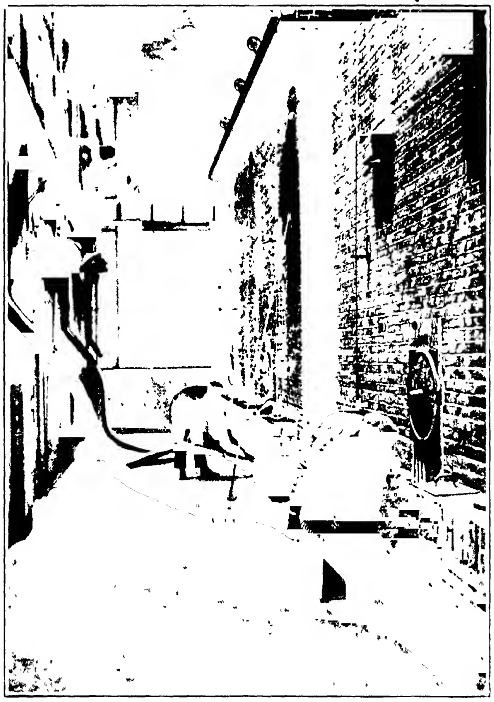


FIG. 55.—CLEANING ECONOMISERS WITH FLEXIBLE SUCTION PIPES.

A mast and gaff rig with a Hunt railway on the same basis would cost about £1,500 to install, and require two men to work it.

PNEUMATIC ASH CONVEYERS.

Pneumatic ash conveyers in connection with boiler-houses are built as a speciality in this country by Babcock & Wilcox, Ltd., and Ed. Bennis & Co., Ltd., and although we have already dealt at some length with this subject as a whole, we cannot refrain from again referring to such installations before concluding the subject of the mechanical equipment of boiler-houses, on account of the extended use of such pneumatic plant over a wider range of usefulness. The principle is, of course, the same, and needs here no further elucidation, while the development of the essential details of the system as now advocated by Ed. Bennis & Co., Ltd., make such an installation applicable not only to the handling of ashes, but also for the cleaning of the main flues up to their entrance into the chimney, cleaning out pits alongside and the space and chambers beneath economisers without the attendant having to enter the latter chamber.

The pipes for these auxiliary purposes can be kept entirely separate from the main ash pipes, or can be joined to them as desired. These pipes are laid in the cleaning-out pits alongside the economisers and pass into the main flues at the entrance to the chimney. The remaining portions of the pipes may be carried in trenches below the ground, or be fixed in any convenient way above ground until they join the ash mains or the ash receiving hopper, as the case may be. With these auxiliary mains and their flexible branches the dust is removed

FIG. 56.—CLEANING FLUES WITH FLEXIBLE SUCTION PIPE

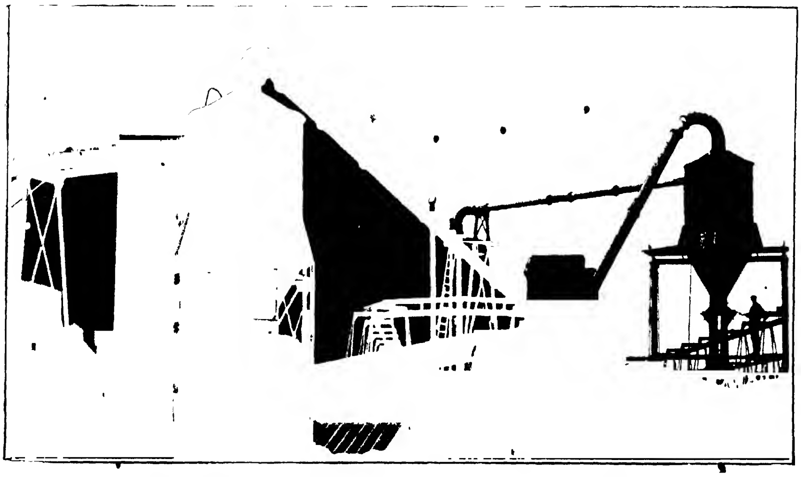


FIG. 57.—ASH SUCTION PLANT SHOWING FAN HOUSE AND RECEIVING HOPPER

from beneath the economisers. Only one or two such flexible branches are necessary for the installation, as they can be changed from place to place and fit quite a number of branch attachments Each flexible branch is provided with a "Bennis" patent lance, so that the suction end can be inserted into the chamber beneath the economiser. The main flues are cleaned out by similar flexible branch suction pipes. A special feature of the suction nozzles is their immunity from choking even if plunged into a large heap of flue dust Figs 55 and 56 show men using these flexible branch pipes

A few main features of the Bennis system are worth recording The ash pipe or main is so arranged that an intake with air cut-off is placed in front of each boiler flue, which communicates with a small hopper covered with a grating, which latter the ashes and clinkers must pass. The pipes are of cast iron, with flanged ends and joints, and can be arranged to rest either on the bottom of the blow-off trench or on pillars built into the trench Bends in these mains are avoided as much as possible, and with the few which are indispensable ample provision is made to replace the extra wear at these points easily and expeditiously Handholes with airtight doors are furthermore provided, so that any obstruction accidently lodged in these bends may be removed

The elevated ash bunkers are of the usual cylindrical type with conical extremities, and are built of mild steel plates lined with concrete or brickwork, with angle iron rings placed inside the tank to support the lining The upper cone, of course, joins, as usual, the ash main, while the lower one is fitted with a patented balanced discharge valve, which allows of any required quantity being immediately delivered into the railway truck or cart placed underneath A water spray is provided inside the upper coned portion of the ash receiver, and a patent water sealed pipe is taken from the lower portion of the ash receiver into a "sump" to get rid of any excess water which may have been put into the ash receiver.

A foul air pipe is connected to the top of the ash receiver to carry the air to the patent cleaner, which consists of a water sealed vessel filled with rows of water-sprayed bafflers which catch any dust or fine particles which might otherwise be carried into the exhauster The large water seal at the lower end of the cleaner acts as a safety valve in case of undue pressure or exhaust in the apparatus The exhauster is of the rotary blower type and of ample capacity to maintain a sufficient vacuum for the capacity of the plant

Fig 57 shows a portion of one of the ash suction plants recently erected by Messrs Bennis in a factory for the manufacture of high explosives

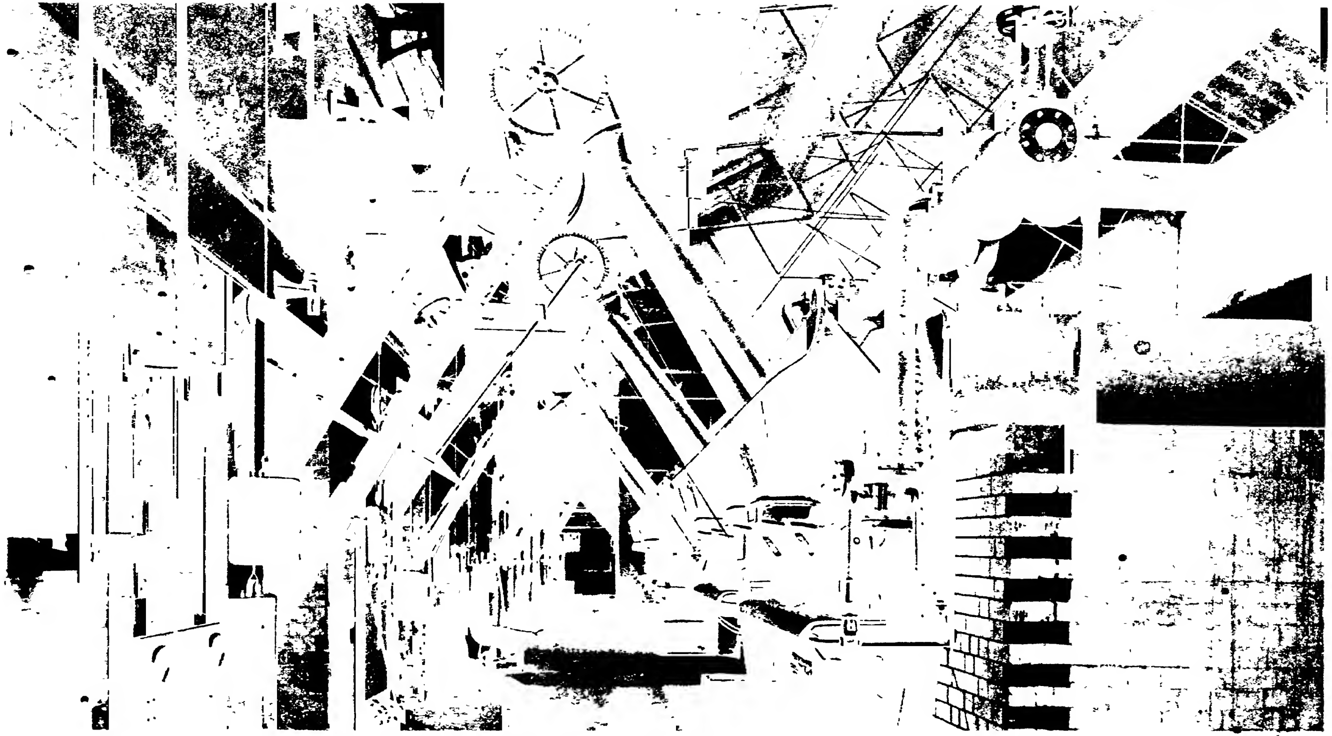
MECHANICAL OR AUTOMATIC STOKERS.

No modern boiler-house installation can be pronounced complete without mechanical stokers, and conversely the mechanical stoker cannot be used to its best advantage as a labour-saving machine unless it works in conjunction with a mechanical equipment.

Intermittent feeding of a furnace (as done by hand) cannot be pronounced scientific, since combustion is not intermittent but continuous.

Theoretically the fuel should be replenished at the same rate at which it is consumed. We find an illustration of this in our domestic hearth, where we feed the fire intermittently, and we therefore experience a period when the fire has just been made up, when it is black and we get but little heat from it. Then comes a period when it gets too hot, and finally it lacks in shedding comfort by getting too low, and at this period we add more coal, and repeat the operation over and over again. If we would care to take the trouble to put on a small amount of coal frequently and regularly we would have a fire giving continuous and uniform heat, and we would expend our fuel to the best

PLATE VII.



Coal Elevators and Mechanical Stokers at the Coventry Corporation Electricity Works.
Erected by Messrs. ED. BENNIS & CO., LTD., Little Hulton.

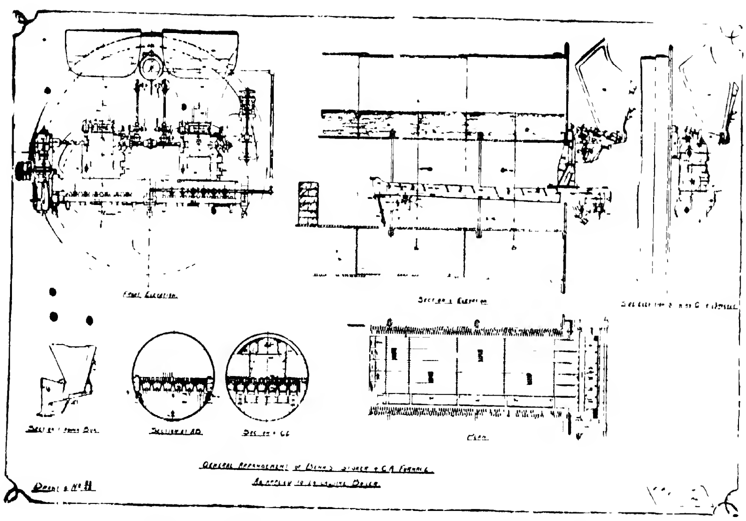


FIG. 58. GENERAL ARRANGEMENT OF BENNIS SPRINKLER STOKER

advantage. In the domestic hearth this may be more trouble than it is worth, but with a power plant where we burn tons instead of pounds it is altogether different and very well worth while, for what is a mere discomfort to us at home is a financial loss to us in business. A good mechanical stoker will feed the fuel at the same rate at which it is consumed.

The advantages of the mechanical stoker over hand-firing are, a saving in labour, a saving of from 10 to 20 per cent in fuel, a more perfect combustion of the fuel and therefore increased boiler capacity and a more or less smokeless chimney, and a greater facility to regulate the coal consumption in accordance with the demand on the boiler. The greatest saving in labour can only be realised in boiler-houses so equipped that the coal drops automatically into the hopper of the stoker, and then one man can look after such an installation for 5,000 to 6,000 h.p., or ten times more than he can attend to by hand-firing. With a mechanical stoker and low grade coal an efficiency can be obtained as high as by hand-firing with a better grade of coal. The fact that with mechanical stokers the fire doors need not be opened every few minutes, makes it possible to have an even and constant air supply, and the regular and continuous feeding ensures the efficiency of the consumption of the coal and a complete combustion of the fixed carbon. A perfect combustion spells economy and a smokeless chimney, as there are as many heat units in the volatile matter of combustion as in the fixed carbon, and smoke is nothing less than hydro-carbon gas, or free carbon, escaping not only wasted but constituting a nuisance as well, a lavishness for which no one has yet received a word of thanks. Such volatile matter must be passed through the incandescent fuel on the grate or be mixed with a proportionate amount of heated air until it has been consumed, if full benefit is to be derived therefrom. All this can be achieved to a greater or lesser degree by a well designed mechanical stoker.

THE SPRINKLER, COKING, AND CHAIN & UNDER-FEED STOKERS.

The four principal types of stokers are the following:—I. The Sprinkler type; II. The Coking type; III. The

Chain or Travelling Grate type; and IV The Underfeed type.

The Sprinkler Stoker throws a small quantity of coal at frequent intervals over the grate surface. A perfect sprinkler stoker affords a regular out-

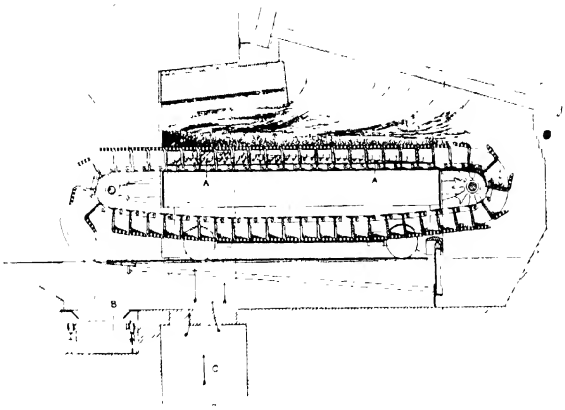


FIG. 59.—LONGITUDINAL SECTION THROUGH CLASS "A" TYPE TRAVELLING GRATE STOKER OF THE UNDERFEED STOKER CO., LTD.

put of steam under the most trying conditions, and its flexibility by adjustment permits a rapid response to urgent demands for increased steam. Minimum labour costs, low fuel bills and smokelessness are a few of the leading advantages that accrue where the sprinkler stoker is in operation.

The fuel fed into the hopper of the Bennis sprinkler stoker (Fig. 58) is led to the front of the pusher-plate where it is evenly pushed over a ledge formed by the base of the feeding box. The weight of fuel pushed is regulated, the fuel being deposited on to a flat plate called the shovel box, and then projected into the fire at intervals by an angular shovel actuated by patent pneumatic gear and effectually scattered over different portions of the grate where and as the fire requires it. The pneumatic gear actuating the shovel, which includes an air cushion to obviate the possibility of shock or jar on the boiler front, is noiseless in operation.

An integral portion of the sprinkler stoker is the self-cleaning compressed air furnace, which prevents clinkering, and ensures clean fire-bars.

With the *Coking Stoker* the coal is fed gradually and at regular intervals by reciprocating feeder rams to the

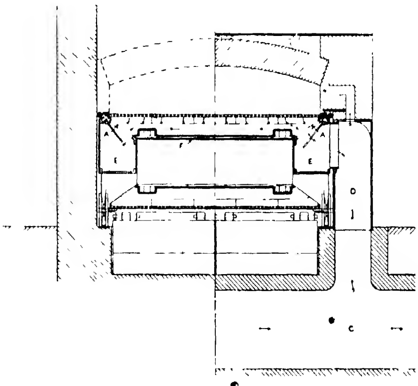


FIG. 60. CROSS SECTION OF FIG. 59

front edge of the furnace, where the coal is coked. The gases which escape by this process mix with the proper amount of air and move over the incandescent fuel and are consumed before leaving the combustion chamber, while the coked coal is advanced by the fresh coal and completes its combustion on the grate until the fixed

carbon is consumed, and the ashes are deposited at the back of the grate. This process may be assisted by a travelling or chain grate.

The essential difference between the sprinkler and the coking types is that in the latter the combustion of the volatile hydrocarbons is effected at a different portion of the grate surface from the combustion of the fixed carbon or coke An independent air supply is sometimes provided for the combustion of each portion of the fuel. In coking stokers, as we have seen, the fuel is generally fed on to the front of a moving grate, the volatile portion being expelled and burnt whilst the remainder is being conveyed towards the back of the fire by the movement of the grate surface. The incombustible portion of the fuel (ash) is dropped into a chamber behind the grate. The movement of the grate surface may be reciprocating or it may be a continuous movement backwards.

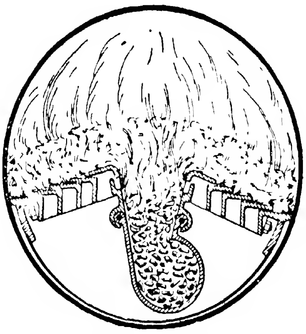


FIG 61 —DIAGRAM SHOWING PRINCIPLE OF UNDERFEED STOKER FOR INTERNALLY FIRED BOILERS

The relative advantages of these two types of meghanical stoker depend largely on the class of fuel to be burnt ; but it is generally agreed that stokers of the sprinkler type will usually generate more steam from a given boiler and with at least equal efficiency. On the other hand, machines of the coking type can be worked smokelessly with less skill on the fireman's part than is needed by sprinkler machines.

The Chain or Travelling Grate Stoker consists of a coking stoker in conjunction with an endless flexible band which slowly revolves towards the back of the grate, moving the coal through the various stages of combustion until the ashes are rejected at the back It forms a complete unit and may be entirely removed if repairs are needed.

In Figs. 59 and 60 the Class "A" travelling grate stoker of the Underfeed Stoker Co, Ltd, is represented in longitudinal and cross section A is the air chamber and B the ash conveyer but the ashes can equally well be dropped at the back of the grate, when no conveyer is needed but merely a hopper C, D and E are air ducts

The Underfeed Stoker requires that the new coal be forced underneath the already incandescent fuel Here the coking process takes place and the gases pass through the incandescent fuel and are consumed before leaving it. Fig 61 gives a very good idea of the principle, which is however modified in the Class "E" stoker to be described later.

This important subject, one of the principal ones in boiler-house economy, cannot here, for want of space, receive the close attention which it deserves, and we can only give sufficient information to drive the fact home to steam-users that mechanical stokers should be installed now to replace hand-firing. The principal makers in this country of the different types of stoker are —The Sprinkler Stoker. Ed Bennis & Co, Ltd, Meldrums Ltd., J. Proctor, Ltd, and the Triumph Stoker, Ltd The Coking Stoker: Ed. Bennis & Co., Ltd., J. Hodgkinson, Ltd., Meldrums Ltd., J. Proctor, Ltd, and T. & T. Vicars The Chain or Travelling Grate Stoker. Babcock & Wilcox, Ltd., Ed. Bennis & Co., Ltd., and the Underfeed Stoker Co, Ltd. The Underfeed Stoker: Underfeed Stoker Co., Ltd., and Erith's Engineering Co., Ltd. Most of these stokers are well known and have been repeatedly described and illustrated, so

that we will omit details of at least the sprinkler and coking types.

The specific conditions for which the different types of mechanical stoker are most serviceable are, for burning low grade coal and for high duty the sprinkler and particularly the underfeed stokers can be recommended. For smokeless chimneys, moderately good coal, and low duty, the coking stoker is best, and for water-tube and return-tube boilers the chain or travelling grate stoker should be used.

Concerning the peculiarities of mechanical stokers, it may be mentioned that the underfeed stokers are not all self-cleaning and those that are not

type of the Underfeed Stoker Co In this stoker the coal is fed in by a sliding bottom instead of by a helix. The number of strokes may be varied from one in three minutes to fifteen per minute, and at each stroke about 6 lbs. of coal are carried to the furnace. The movement of the piston of cylinder C of the steam motor is transmitted directly through the piston rod to the crosshead D, which is bolted to the sliding bottom E. This sliding bottom extends the full length of the trough or coking retort The block B has the same movement as D and E; thus the coal is fed by block B from the bottom of hopper A on to the

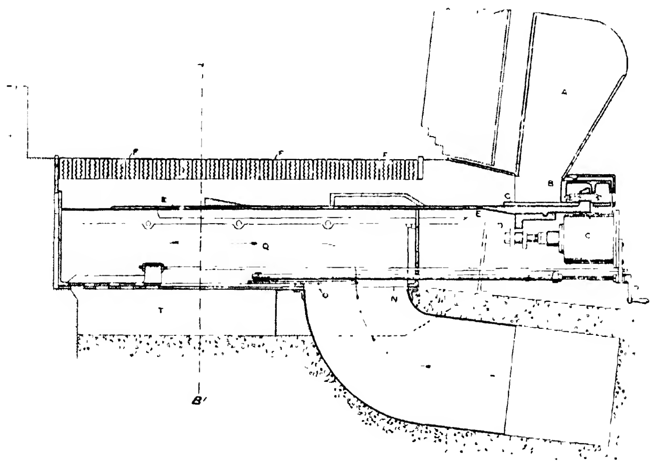


FIG. 62 —LONGITUDINAL SECTION THROUGH CLASS " E " TYPE STOKER OF THE UNDERFEED STOKER CO., LTD

have, therefore, to be cleaned by hand like ordinary hand-fired furnaces through the fire door, and they work therefore at a disadvantage to that extent. There are two types of underfeed stoker, one with an Archimedean screw which pushes the coal in continuously, and which is only used for internally fired boilers (see Fig. 61), and as no low grade coal is used for this type the fact that it is not self-cleaning is not of much consequence. The other type is for externally fired boilers and is self-cleaning.

Figs. 62 and 63 show longitudinal and cross sections of the Class " E "

sliding bottom E, which not only carries it to the back end of the furnace, but forces it to rise the full length of the trough. As the coal rises it is flooded on to the bars F. These bars are alternately moving and fixed, the moving bars working transversely to the retort. On the bottom of each moving bar are cast two lugs which engage with the bulb of the longitudinal rocking bars H shown in the cross section, Fig. 63. These rocking bars in turn receive their movement through the agency of two spirals and nuts, which mechanism is entirely outside the furnace. The nuts are

bolted to the crosshead D and, therefore, reciprocate with the bottom E, (see Fig. 62) It will be seen that the reciprocation of the nuts causes the spiral to rock to and fro

The movement of the grates, in addition to carrying the burning fuel to the sides of the furnace, also conveys the clinker down and deposits it on dump plates K, which are fastened to the hinge-bar L. This hinge-bar is actuated by a lever placed outside the furnace, to dump the accumulation of ash and clinker into the ash-pit.

One of the important features of this stoker is the distribution of the air, which enters the stoker through the aperture N, controlled by the wind gate O This wind gate is adjusted by the crank P. The air upon entering the wind box Q, passes upward along each side of the trough or retort, and is discharged, partly through the holes R, into the retort The remaining air passes through the bars F, which it will be observed are made hollow These bars, however, have no openings in their upper surfaces, and no air can find its way into the fire above until it has passed through the aperture S at the lower end of the bar, from which aperture it is discharged into the air chambers T. From here the air rises and passes through the small spaces between the bars into the coked fuel. The temperature of the air in the air chambers T is in this way raised to from 350° F to 400 F. The pressure of air in the chambers T varies from zero to $\frac{3}{8}$ of an inch of water.

All sprinkler stokers offer the advantage that they can be hand-fired in the case of a breakdown of the mechanical stoker. The same applies to some of the coking stokers All sprinkler and coking stokers are fitted with steam jets for cooling the fire bars. In the case of the Bennis and Meldrum stokers the same jet serves the double purpose of forcing or controlling the draught With the underfeed type a fan is used in the place of the steam jet. For chain grate stokers neither jet nor fan is necessary, as only about one-third of the grate surface is exposed at the time to the fierce fire while the rest is cooling All sprinkler and coking stokers have moving or self-cleaning grates In order to get rid of the clinkers the expediency is sometimes resorted to of giving the grate a downward direction, but this appears to be a mistake, as the back end of the grate is then furthest away from the boiler just at a point where it should be nearest, owing to the fire being less fierce there.

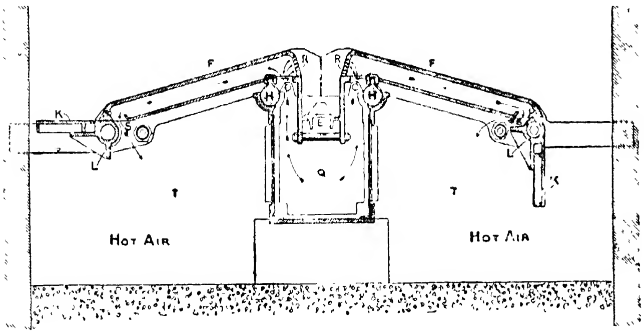


FIG. 63 —CROSS SECTION OF FIG 62

There are many types of stokers all differing in details of construction, for all of which advantages are claimed concerning complete combustion and smoke prevention, but we will not sit in judgment upon them.

What is of great importance in industrial war economy is the fact

already hinted at, that low grade coal can be used with underfeed stokers, preferably with forced draught. The first essential when dealing with low grade fuel is to maintain a high furnace temperature, considering the small proportion of combustible matter to be consumed. Under ordinary firing conditions with natural draught these temperatures cannot be maintained with such fuel. With forced draught, however, the rate of combustion can be materially increased and the temperature maintained to ensure the rapid ignition and consumption of all the combustibles in the fuel. As a matter of fact with the Class "E" stoker of the Underfeed Stoker Co. coal containing as much as 48 per cent. of non-combustible matter, and even coke breeze and anthracite slack, have been successfully used. This important fact cannot be over-estimated, particularly at this period. It has been realised by a few since the war broke out, and there has been quite a decided movement, especially at collieries, to burn under boilers such low grade fuel as was formerly thrown on the dumps. The South Metropolitan Electric Light & Power Co., Ltd., have introduced the first boiler installation in such power plants fired entirely and successfully with coke breeze. The furnaces have been several weeks together unassisted by coal without letting the fires down. Mr Henry W. Bowden, the Company's Engineer-in-Chief, was responsible for this innovation, when he found it expedient to secure low generating cost owing to an increasing demand for power at a very low rate. The venture resulted in a reduction of the coal bill for 1915 of approximately £900, for practically the same output as in the preceding year. The price of the coke breeze was then 6s. per ton. Boilers so fired are almost invariably operated under impelled-draught conditions and at their full normal capacity. At the present price of 8s. per ton coke breeze is still the best fuel value at present obtainable in London. The makers will guarantee an evaporation of 6 lbs. of water per lb. of "breeze," and rates of combustion exceeding 30 lbs per square foot of grate surface per hour have been maintained with automatic stokers of the underfeed travelling grate type.

Underfeed stokers are also burning fuel described as colliery waste, band pickings, washer dirt, and the like. While this fuel is very dirty it is usually comparatively dry. Washer dirt, slurry, etc., while containing about 30 per cent. of ash also contain 30 per cent. or more of water. These fuels burnt at the collieries enable the colliery management to produce steam very cheaply, whereas failing its combustion they would have to go to some expense to arrange for the removal of this material. Frequently it cannot be stored in high heaps, as these heaps fire through spontaneous ignition.

The second essential is to provide for the removal of the ash and clinker from the grate, so that it does not affect the combustion of the fresh fuel which is fed to the furnace. The travelling grate stoker will do this.

Almost since the beginning of the war people have been talking of the need for national economy, especially in connection with our industries, and there is no better opening for such a movement than in the economy of the boiler-house, where fuel is converted into steam. Most engineers are aware that the average boiler-house is a shocking example of lack of economy, due to antiquated methods of steam generation, the net working efficiency* the average of 100 installations, including 39 with automatic stokers - being only a trifle over $55\frac{1}{2}$ per cent. (that is, out of 100 lbs of coal put into the fire $55\frac{1}{2}$ lbs are being used to produce useful steam, the other $44\frac{1}{2}$ lbs. being wasted), whereas a boiler plant run on scientific lines should give an efficiency of over 60 per cent.

*D Brownlie and H Green.

THE HANDLING OF MATERIAL IN GASWORKS.

It is not within the province of this article to comment upon the merits or otherwise of the different methods of carbonisation, the more so as even gas experts cannot agree which is the best. One thing, however, is beyond all controversy and that is the merits of the newer methods over the old ones as far as the saving of labour is concerned. The old horizontal retort had to have its fill of coal spooned in like a baby, or pushed in like a Surrey capon, while after carbonisation the coke had to be pushed out again *a la* sausage machine. This progenitor of retorts has held sway for such a length of time that it is not more than natural that the feeding

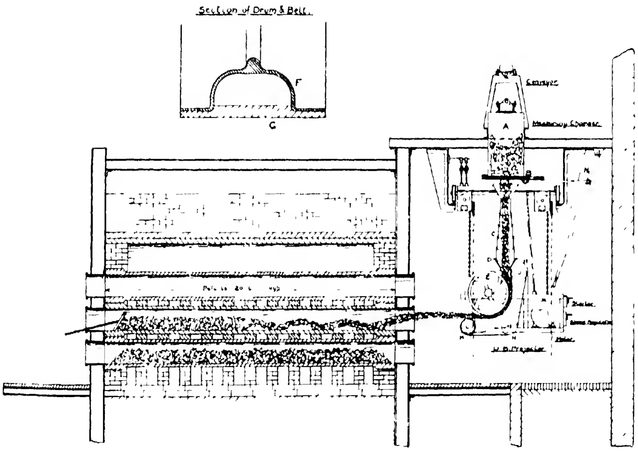


FIG. 64 DE BROUWER PROJECTOR CHARGING MACHINE, MADE BY W. J. JENKINS & CO., LTD

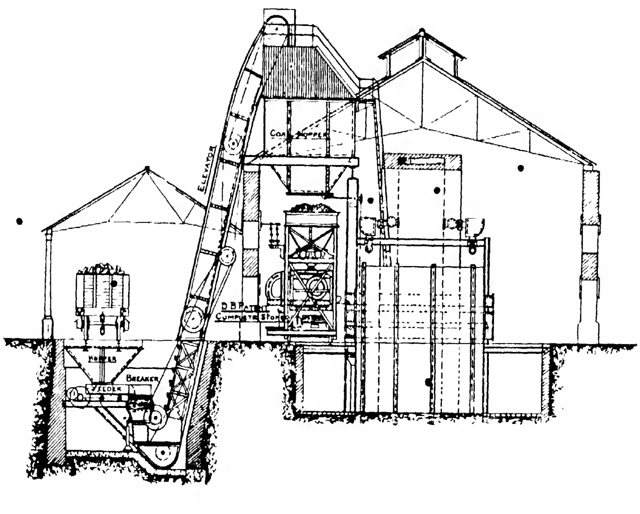


FIG. 65.—TYPICAL COAL-HANDLING PLANT BUILT BY W. J. JENKINS & CO., LTD.

and discharging should now be done by the most up-to-date machinery. One of such charging machines, that of De Brouwer, is illustrated in Fig 64. It shows the coal conveyer overhead and the portable charging device suspended from two rail tracks. The coal is thrown into the retorts by centrifugal force.

At the second stage the retorts are sloping at an angle of about 45°. Here the charge of coal can be dropped in by gravity and the coke dropped out in like manner after carbonisation, and the latest development, the manner no matter of what type the retorts may be.

But before doing this we will just look at a few interesting drawings which have, together with Fig. 64, been prepared by Mr J. E Lister, A.M.I.C.E., A.M I M.E., of Messrs. W. J. Jenkins & Co, Ltd, for an interesting paper on "Modern Coal and Coke Handling Machinery As used in the Manufacture of Gas," which was read by him as recently as the 3rd April 1916, before the Society of Engineers, with whose kind permission the illustrations, Figs 64 to 68, are here reproduced.

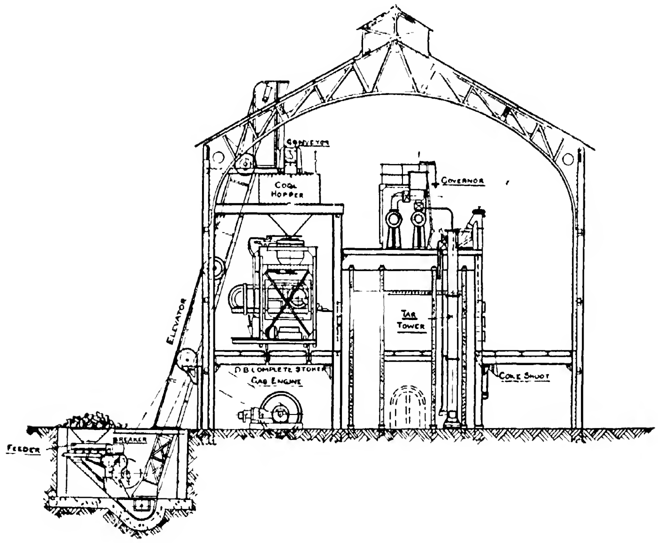


FIG. 66.—COAL-HANDLING PLANT AT THE OSAKA (JAPAN) GAS-WORKS

vertical retort, can receive a continuous stream of coal and reject an equally continuous stream of coke, all by gravity and automatically.

The supply of coal to the retort-houses of gas-works is practically identical to that to boiler-houses, which latter has already been fully dealt with, so that it is left to us to confine ourselves more particularly to the handling of coke, both hot and cold. The type of retort does not concern us here, as we are dealing with the coke as it leaves the retorts, and it must be dealt with in a similar

The complete arrangement of a typical coal-handling plant for horizontal retorts, as recently erected at many gas-works, is shown in Fig 65, with coal breaking plant, and with an elevator of 25 tons per hour capacity and a central overhead storage bunker holding about 40 tons of coal. The elevator is of the ordinary bucket type with malleable iron buckets bolted to a manganese steel chain. Cast-iron skidders are fixed to the buckets and these run on cast-iron wearing strips bolted to the elevator framework, just the same as those previously mentioned

for boiler-houses An elevator of this type with buckets 12 in. wide by 9 in. deep will raise about 25 tons of coal per hour when running at 120 ft. per minute, and about 5 h.p. should be allowed for a lift of 70 ft. to 80 ft.

Fig. 66 shows a complete plant which, together with the steel framed retort house, was recently supplied to the Osaka (Japan) Gas Company In this case the combined charging and discharging machine is fitted with a weighing chamber, and a hopper holding a 24 hours supply of coal is arranged in front of each bed of retorts The elevator, which is of the usual enclosed type, delivers the coal on to a push-bar conveyer which distributes it into the various hoppers This arrangement, though more expensive than the central hopper plant in first cost, is rather more economical in working, as with the larger capacity of the storage hoppers, it is only necessary for the coal plant to be worked during the daylight shift Precisely the same type of plant is used for inclined retorts, only the charging machines are not required The same applies to vertical retorts. Figs 67 and 68 show longitudinal and cross sections through a retort-house with vertical retorts fed by a gravity bucket installation.

The question whether coke can be handled more economically by mechanical means than by hand, has been a leading one which has exercised the minds of gas engineers for years. It is exceedingly difficult to arrive at a definite conclusion on this subject, as those gas-works which have installed plant for handling coke employ a variety of systems and the conditions are likewise different

When mechanical conveyers were first used for hot coke, the late Mr W R Chester, of the Nottingham Gas Works, compiled most carefully all

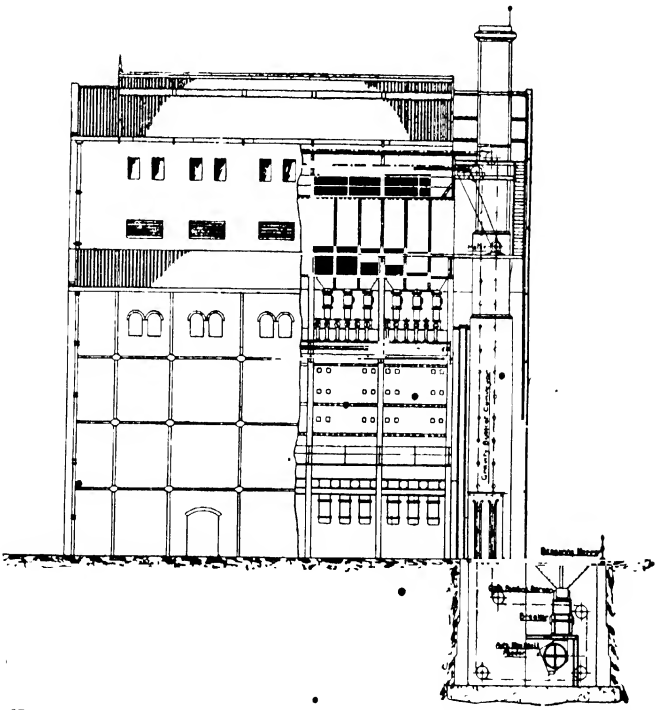


FIG. 67.—LONGITUDINAL SECTION THROUGH A RETORT-HOUSE WITH VERTICAL RETORTS FED BY A GRAVITY BUCKET CONVEYER

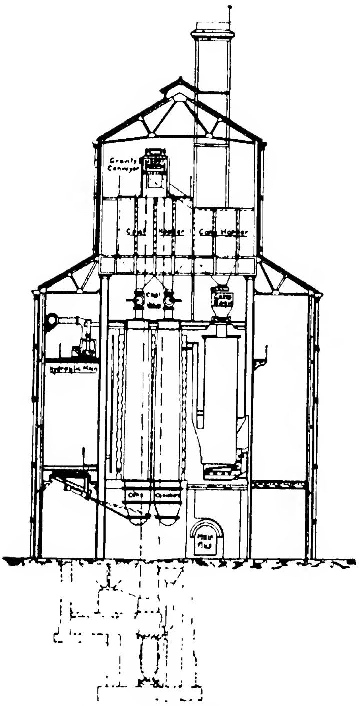


FIG 68 CROSS SECTION OF FIG 67

data in connection with his plant during a period of six years, which he generously published at a meeting of Gas Engineers at Glasgow in 1901, which made it apparent that when handling material of a destructive nature like coke, a point may be reached when hand-labour is more economical than machine-labour, but of course such a conclusion must not be rashly accepted, as this depends upon the cost of hand-labour (which used to be much less) and on the efficiency and wearing qualities of coke conveyers (which used to leave much to be desired). Even in those early days it was estimated on the basis of Mr. Chester's figures that the cost of handling by machinery the hot coke from the retorts by a hot coke conveyer, an elevator, and an ordinary conveyer for distributing the coke over the heap in the yard, cost per ton of coke handled, for repairs and renewals .. .. 5.518d.

$3\frac{1}{2}$ per cent. interest on capital outlay £3,398 .. 0.952d.

6.470d.

while it is estimated that, with the state of the labour market at that time, a man removing 15 tons per day in barrows from the stage-floor of the retort-house to the coke heap in the yard, the cost of hand-labour came to 4d per ton, and with the maintenance and renewals of barrows at 1d per ton, to a total of 5d., or $1\frac{1}{2}$d. less than by mechanical means Under present day conditions there is a sufficient balance on the other side to effect a substantial saving when handling even this most unsatisfactory of all materials by machinery. The wear and tear with machinery for handling coke can be up to twenty times as much as it is with coal, which latter material in powdered form almost lubricates those parts which the coke abrases

But it is not only the hot coke which requires attention by mechanical plant. After quenching, the coke has become less destructive than when in its incandescent state, and can at least no longer distort the machinery designed for its conveyance, but instead of the latent heat we have now to deal with the corrosive moisture and the fine coke particles which enter into and disintegrate the mechanical parts with which they may be brought into contact. We thus see that while hot-coke conveyers may be of the push-plate or bar type, preferably the De Brouwer type, where the bars and carrying chains are more or less protected by the quenching water in which they are submerged, the conveyers for quenched coke are best of the Zimmer reciprocating trough type, as with this the material does not come into contact with any mechanical parts. Such conveyers have, moreover, been developed partly into screens, so that the coke can be stored in silos or heaps in a marketal condition, *i.e.*, screened and sized.

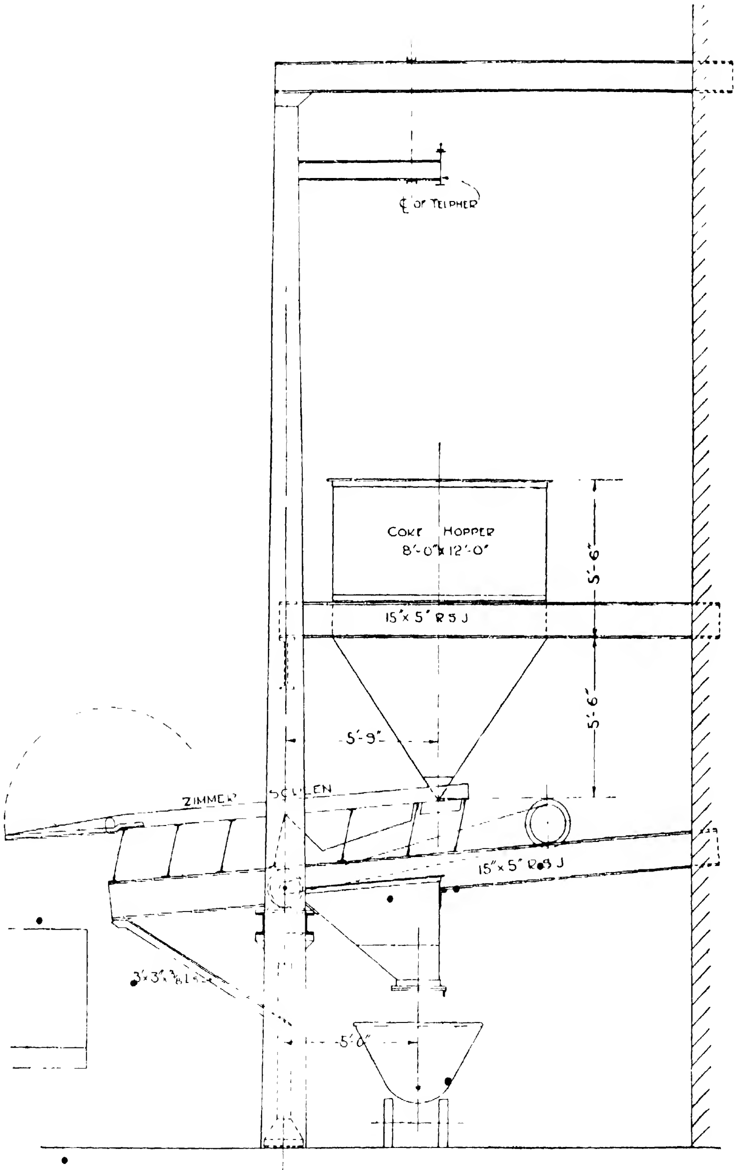


FIG. 69.—COKE LOADING SCREEN AS SUPPLIED TO THE LEEDS CORPORATION GAS-WORKS

Mr. Lister advocates in the paper already quoted two principal methods of dealing mechanically with hot coke: (1) by means of conveyers, and (2) by means of transporters or telphers. Each method has its advantages, and the question as to which shall be adopted must be decided entirely by the local conditions. In many cases a combination of the two is the ideal arrangement, a conveyer being used inside the retort-house and a telpher outside in the coke yard.

The chief advantages of a conveyer are that it is continuous in action, and therefore does not restrict the speed of the stoking machinery, and when once started to work it is practically automatic in action, and does not require a man in constant attendance.

The principal advantages of a telpher plant are, the great area of ground that can be covered without an excessive expenditure and the small amount of handling received by the coke, with a corresponding decrease in the production of breeze. At the same time, with a plant of this type, the speed of the stoking machinery is regulated by the time taken by the telpher to run out with a load, deposit it at the required spot, and return for a fresh charge. A man is required constantly on each telpher, which increases the labour cost, but the cost of upkeep is light. A telpher plant will cost approximately £450 for the transporter itself and £3 to £4 per foot run for the track, the cost depending mainly on the number of curves, and the height of the track above ground level and the load to be carried.

A conveying plant will probably cost from £4 to £6 per foot run, the lower figure being the cost of the portion inside the retort-house, where the trough and return path can be supported from the floor structure, and the higher figure including supporting trestles or other structure for carrying the conveyer at a suitable height above the ground in the coke yard. As mentioned above, the ideal arrangement is frequently a combination of the two methods. By arranging a conveyer in the retort-house, with a hopper at the end of the house, capable of holding all the coke produced in one draw, the stoking machinery can work at its full speed, and the telpher can distribute the coke to the required points between the rounds, when there is a man available who might otherwise be idle.

A modern way of dealing with the problem by telpher is to receive the incandescent coke from the retorts in a kind of oblong iron basket, which should preferably hold the contents of one retort. This receptacle is manipulated by a man telpher. It is lowered by the telpher winch to be filled, then raised, taken outside the retort-house, and there lowered into a capacious quenching vessel full of water, raised again after quenching, after which the telpher follows its track, which leads over the centre of a series of silos, and there the coke is discharged into a Zimmer reciprocating conveyer and screen, which eliminates the "breeze" and delivers it into the first division of the silos, small coke into the next, and the large through outlets fitted with slides into the remainder of the silos.

The silos are sufficiently high above the ground that their contents may be drawn off into vehicles by merely opening a shoot. The coke is thus never touched by hand-labour from the time it leaves the retorts red hot to the time it is carted away by the purchasers. One of the many gas-works so fitted is that at Southampton, which is one of the most up-to-date plants.

Another method of stacking coke in the yard is by means of a locomotive crane and skip on an elevated track, which practically eliminates the possibility of a breakdown, but with this method no screening of the coke is provided for. This may, however, be performed in a separate screening plant to which the coke can be delivered by the crane from the stock-heaps.

Sometimes the quenched coke is dumped by a telpher into bins without

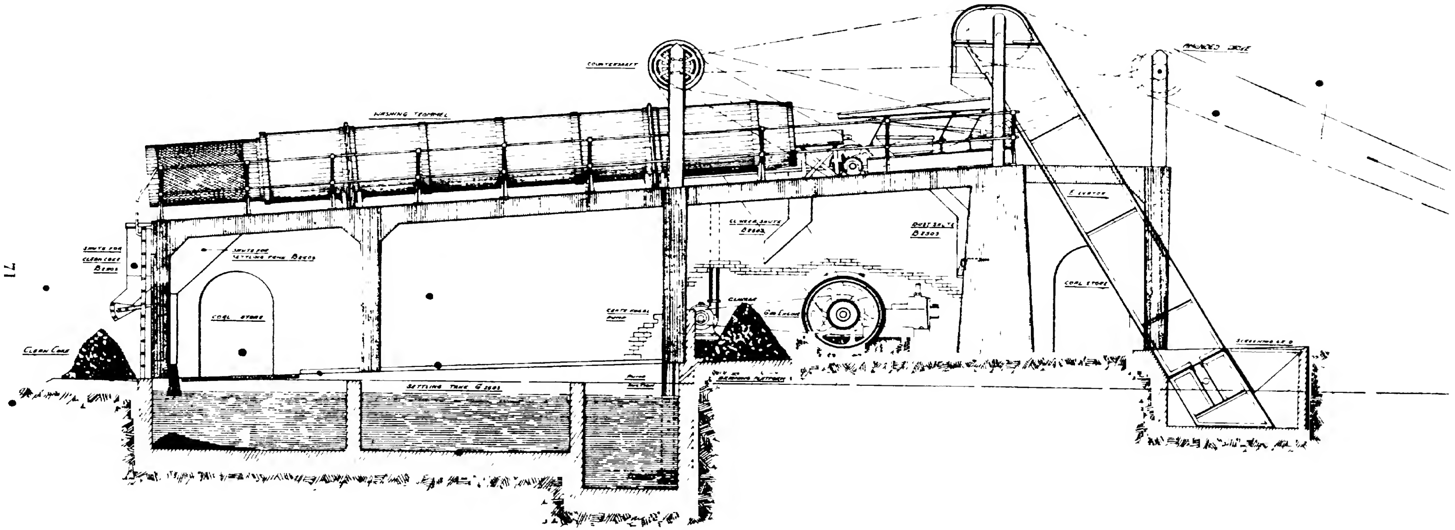


FIG. 70.—PAN ASH WASHING PLANT AS ERECTED AT THE BRENTFORD AND OTHER GAS-WORKS

being previously classified, and an extensive plant of this kind has been erected by Strachan & Henshaw, Ltd., at the Leeds Corporation Gas Works. Fig. 69 shows one unit of the installation. Above one of the coke hoppers the telpher track is shown, and one of the combined conveyers and screens of the Zimmer Conveyer Co. receives the coke from the hopper by the mere opening of a slide. The conveyer is 10 ft. 0 in. long, but the screening surface is only 3 ft. long, which is sufficient to eliminate all the "breeze" and deliver the screened coke into carts The "breeze" drops into a hopper, and is at intervals removed by a narrow gauge truck. This installation at Leeds has a battery of seven such conveyer-screens under an equal number of hoppers.

Notwithstanding the fact that the sheet steel trough of a reciprocating conveyer is worn out in one to two years, and even the cast iron trough of coke conveyers must often be scrapped in two years, while the chain may last three or four years, it is found economical to employ such screens and conveyers, as nowadays the coke cannot be conveyed by hand barrows from the retorts and screened at the heap for less than 1s. per ton.

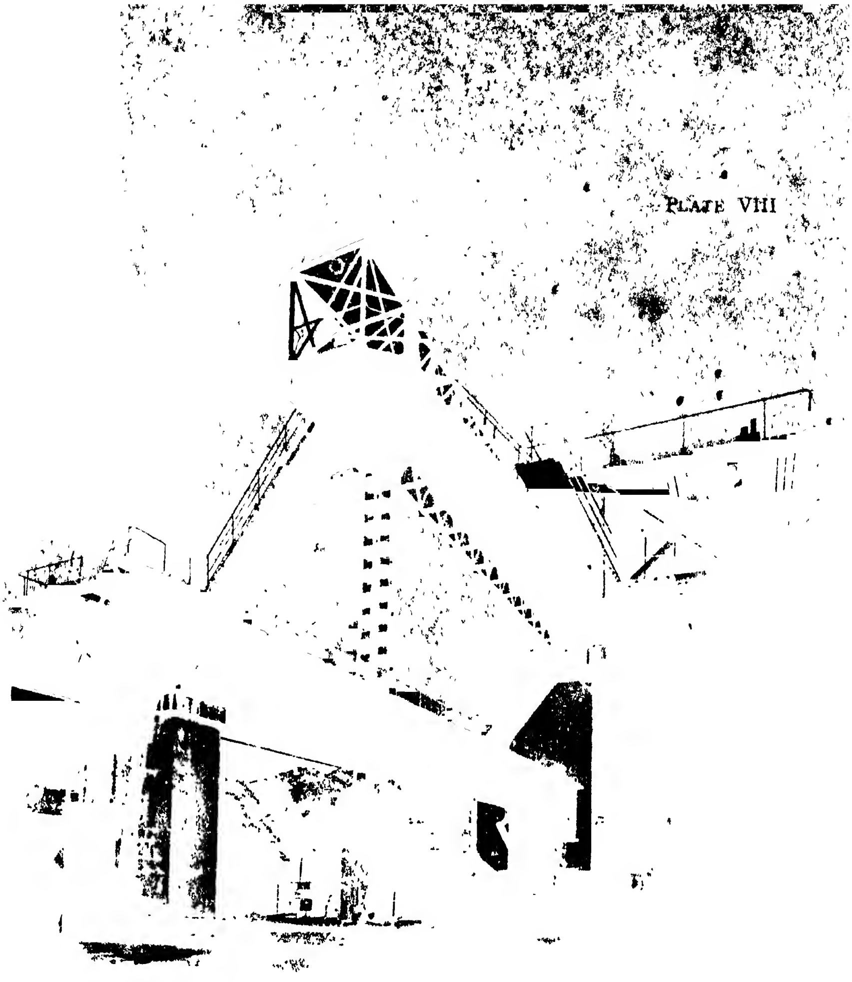
An important new development has quite recently entered into the economy of the gas industry. As is well known, coke is exclusively used for firing the furnaces of gas-works retorts, and the resultant clinker contains a large percentage of good coke Hitherto the "pan-ash" as this clinker is called, has either been hand-picked or given away, or even carted away for a monetary consideration, as most gas-works are in crowded districts and too congested to permit any accumulation of unsaleable by-products. It may be safely estimated that between 40 and 50 per cent. of the so-called clinker is good coke, and the recovery of this by mechanical means is the object of this departure

The illustration, Fig. 70, shows one type of plant which has recently been erected by the Gordon Harvey Co. for the Brentford Gas Company. It will be seen from this that the "pan-ash" is elevated by an ordinary bucket elevator and delivered on to a Zimmer combined conveyer and screen, where the dust up to ½ in. is eliminated, as this small coke has little value. The remainder is passed by the said conveyer into an inclined rotary trommel, which is provided on its inner periphery with a spiral which, being a fixture, revolves slowly with the trommel. The machine is on the same principle as those used for washing coal at collieries. A centrifugal pump supplies an adjustable jet of water which washes the "pan-ash" into the central portion of the lower surface of the trommel. The coke being specifically lighter than the clinker, passes slowly over the intervening obstructions offered by the spiral one by one to the end of the machine, while the heavier clinker is intercepted by the same spirals, and is thus conveyed back towards the feeding end and there drops out of the trommel on to the ground or into barrows. It will be understood that the internal spiral is disposed in the cylinder in such a way that by its revolution all material fed into it would not be permitted to travel forward but backward, if it were not for the stream of water which alone is responsible for the forward movement of the coke

The clean coke and water pass over a screen at the tail end of the trommel, where the water is drained back to the settling tank to be pumped over and over again, the coke passing out either on to a heap on the ground or into hand barrows.

There are other types of washing machines equally well adapted for the same purpose, but let this example suffice. It is also obvious that such an auxiliary plant for gas-works of greater magnitude can be considerably elaborated by the introduction of screens and bunkers into which the coke can be classified. The coke so reclaimed is suitable in every way for firing under boilers, and it is generally used for this purpose on the works.

PLATE VIII



Part of an Installation of 5 Gravity Bucket Conveyors for handling and distributing coke, each of which handles 30 tons of coke per hour.
Erected at Provan Gas Works, Glasgow, by Messrs. BABCOCK & WILCOX, LTD., London.

FLOATING LOADING DEVICES.

With the exception of the gigantic pneumatic installations such as have been installed at the Millwall Docks and at other large grain centres, there is no mechanical device which will dispense with so much hand labour as the floating loading devices with mechanical equipment. The pneumatic handling of grain at our docks (where one man does now as much as used to be done by eight) leaves nothing to be desired to meet the present demands, while, however, the handling of coal by mechanical means, except at our principal coaling centres and at our naval ports, has been sadly neglected.

Considerable strides have been made of late by our engineers in design and development in this direction, and although we are probably better equipped in this our famous coal country than any other country for mechanically disposing of cargo coal, we lack in some ports the facilities for transferring bunker coal mechanically into ships, and, it is painful to have to say it, in some of our ports we lag behind some of the continental ones, particularly those of Hamburg and Rotterdam. In the Port of London, even, a great deal of hand bunkering may be seen daily, in spite of the dearth of men and the continual labour troubles, and where mechanical means are used they are often of the most primitive kind, consisting, for instance, of a barge with a couple of steam winches, which raise the coal in baskets out of the lighter and then transfer it to the bunkers. By these primitive means, and with nine men filling the baskets in the lighter and emptying them into the bunkers, as well as three men working the winches, etc., in all twelve men, only about 240 tons in 10 hours are handled at a cost of 9d. per ton. Without the winches the output is not more than half this, or one ton per man per hour.

There is not much to choose between this and the way they do it in Japan, as a glance at Fig. 71 will show us, a sight often seen at Nagasaki, the "Portsmouth" of Japan. This lively scene affords plentiful employment to hundreds of men and women, and it differs, alas, but little from some of our hand bunkering, except that it is certainly more picturesque. With this sort of thing going on, it is small wonder that Jack has a sweetheart in every port, and if he has not it is not for want of leisure and opportunity. We do not grudge him this pleasure, but cannot help hoping that less antiquated methods will soon be introduced, thus Jack may have to be less fickle.

In addition to the expense and time wasted by hand bunkering, there is the further drawback in the fact that the ship has to be cleaned down, which is not necessary after mechanical bunkering, not to mention the practical impossibility of loading or discharging cargo when an army of coal-heavers are swarming like ants up and down on both sides of the ship.

The coaling of a navy in war-time is one of the most important items of our national programme just now, but it will not do to pry into those details at the present moment, yet here are matters of interest which cut deeply into the subject under discussion. The naval men, who do at present chiefly what might be called "sentry duty," have plenty of leisure to get coal on board, though such operations are tedious and irksome. The time may arrive, we hope will arrive, when they will be chiefly engaged on more serious work, when it will be of vital importance to replenish the bunkers as expeditiously as possible, as a fighting fleet without adequate coal supply is unthinkable. It has already been mentioned that the coaling facilities at the naval ports appear to be all that can be desired, but coaling on the open sea is the most difficult problem, and there are obviously times when coal must be taken so, as the fleet is often far from its base. We can gather this from past historical experiences furnished by the Spanish fleet in the Spanish-American

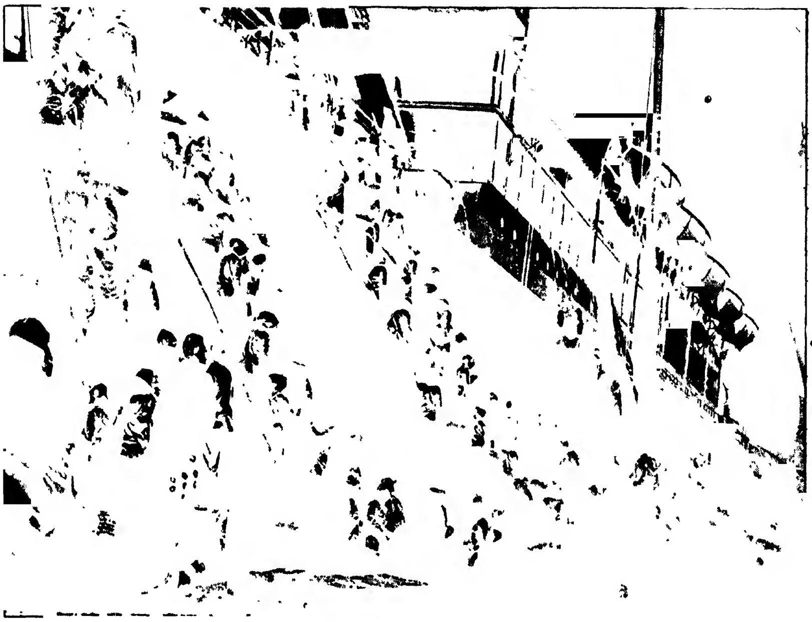


FIG 71 COALING A SHIP BY HAND AT NAGASAKI, JAPAN

War and the Russian Baltic Fleet in the Russo-Japanese War

We have already seen that basket coaling is still considered one of the principal methods. Why this should be so it is difficult to explain, but it must be so because the primitive basket and the block from the rigging has been developed to a fine art instead of being discontinued for a more scientific principle altogether. The common method with one pulley block has been improved by the introduction of a second block A rope of a suitable fixed length, one end of which bears the hook for the basket, while the other end is fixed to some convenient point of the rigging, passes over a block likewise fixed to the rigging of the ship which receives the coal A second block (a "snatch block") is loose on that portion of the rope between the first block and the fixed end of the rope, and to the shackle of this snatch block a hand-rope is attached. When the basket has been hooked to the end of the rope the hand-rope is wound once or twice round the warping end of the ship's winch, which is kept running all the time coaling operations are proceeding. When the hand-rope is shortened by the capstan the snatch block is pulled down and the hoisting rope shortened, which thus lifts the load, and the advantage is that the shortening of the hand-rope is only one-half of what it used to be with the original method, and the process is therefore twice as quick. With a multiplication of such tackle and a corresponding multiplication of men the capacity can be made adequate to the demand With the aid of the drum head or warping end of the winch the load is lifted when the hand-rope is pulled If it is slightly slackened and held still, so that the rope slips on the drum head, the load is stationary, and when quite slackened the load descends

The latest development of this class of tackle is the introduction of the movable electric motor in the place of the fixed steam winch. The prin-

cipal advantage of an electrical winch is its smallness and, therefore, if suitably made, it can be fixed to the rigging of the ship which receives the coal, and there is no limit to the number which can be so employed.

It may be interesting to point out that such electrical plant is largely employed in the German navy, and the *Posen*, in an official test in June, 1908, with such tackle took 642 tons of coal on board per hour. The number of men employed in doing this is not given, but it must have been very considerable, and the only excuse that can be made for what, to an outsider, appears a clumsy method, even with all its refinement, is that the large complement of men on battleships could not be reduced, even if more scientific and labour-saving means were employed, and the crew tackle this unpleasant and dirty work as a part of their ordinary routine. A great many units of the enemy navy are provided with electrical winches of divers patterns, and as we naturally like to know how they do things, a more minute description of their winches may not be amiss. In the first place, one of the types is produced by Simens-Schuckert. The winch weighs 480 kilos, and is easily taken into three parts by the removal of a few bolts. The three parts are

The Motor, weighing	..	230 kilos
The Winding Drum and Gear	.. .. ..	220 ,,
The Starter	..	30 ,,
		480 ,,

The gear of the winch, which includes worm and worm gear, is enclosed in an oil-tight casing. Fig 72 shows an electric winch suitable for suspending from the rigging. The rope which carries the basket is attached at one end to the winding drum, and the motor *m* can be revolved in either direction, for raising and lowering.

Another type, not with a cylindrical drum like the last, but with one narrowed somewhat and rounded inward on the face, like the drum head or warping end of a ship's winch, and manipulated as stated above by pulling or slacking the loose end for raising or lowering, is shown in Fig 73. It is named the "dwarf winch of Wilhelm." The armature *a* is arranged

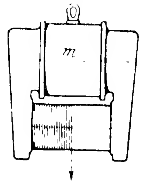


FIG 72 TYPE OF SUSPENDED ELECTRIC WINCH

centrally within the drum, and the spindle by means of a pair of spur-wheels rotates a short countershaft which gears by another pinion into the toothed inner periphery of an annular ring or magnet frame, upon which the winding drum can revolve freely on the rollers *m* whilst the magnets are fitted to the inside. The drum is coupled to the revolving annular ring or magnet frame by the conical friction rings *r*, which are shown black in the illustration, and are normally held out of contact with the corresponding conical surfaces on the winch drum by the springs *f*. As soon, however, as the hauling rope is tightened, a series of bars *o* (which are placed at close intervals around the periphery of the drum) are pressed

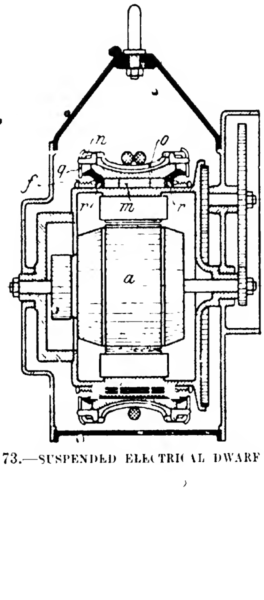


FIG 73.—SUSPENDED ELECTRICAL DWARF WINCH

down. Each bar *o* is coupled to two levers *n*, which in their turn influence the lever *q* so as to force the coupling ring *r* home, when the drum revolves. When the basket is detached the springs *f* immediately uncouple the drum again, so that it can freely revolve and allows the rope to descend for another basket.

This electrical winding gear is built by Simens-Schuckert and Gebr. Korting. The design has since been modified, and is now less dependent upon the many small parts. All the levers *o*, *n*, and *q* have been discarded in the later machines, in the drums of which rectangular recesses have been provided, in which radially moving blocks with conical side cheeks can now act direct upon the rings *r*. These blocks are fitted with springs, which force them back whenever the rope slackens.*

The whole apparatus is enclosed, and can be rolled on deck on broad flanges when out of use, like a barrel, there being no projections, the supporting shackle and the electric connections all being within the periphery of these flanges The supporting shackle is pulled out of its retreat when the winch is hoisted into position on the end of a boom.

The normal gross load is 120 kilos and the lifting speed 2 metres (about 6 ft. 6 in) per second. If the coal has to be raised 7 metres (23 ft.) it takes

4	seconds	to lift the load.
3	,,	for unhooking the load.
3	,,	for lowering the rope.
2	,,	for hooking-on a full basket.
12	,,	for the complete cycle.

The nett load is 100 kilos, or 30 tons, per hour. If three lighters can be moored on each side of the ship and four winches used in each, together 24 winches, 720 tons can be delivered on board per hour.

We do not, of course, imply that the foregoing are the only or even the principal means of bunkering employed in the German navy. They have used the Temperley Transporter since 1893, they use mechanically equipped colliers and barges of the Smulders' and other types, and they have, it is believed, marine cableways for coaling under way on the Leue and Adam principles, at least they have spent much time in experimental work with these variations of the marine cableway.

Hundreds of Temperley Transporters have been supplied to the British Admiralty, and a considerable number to foreign navies. It consists of an automatic traveller or running head of either the single or double-purchase type, a beam on which the traveller runs, suspended from a convenient support such as the ship's derrick or a spar between the masts and held in position by guys; and a hoisting rope from the ship's winch for lifting, transporting, and lowering the load. The transporter beam is suspended at a gradient of about 1 in 3, and is so placed across the vessel as to command the hatchway and quay or lighter simultaneously. The beam is from 30 to 65 ft long, in multiples of 5 ft. and for loads of 30 cwt All along the beam and at a pitch of 5 ft. are notches or stops, at any one of which the traveller may be arrested at will by the man at the winch and the load lifted or lowered. The traveller is made to take grabs as in the Spencer Miller gear, but sacks, baskets or skips are more generally used The Temperley Transporter is now made by Sir William Arrol & Co, Ltd Fig 74 shows a "Temperley" in position.

The Sieurin system, which is newer and not so well known as the Temperley, promises none the less to become a most useful unloader for coal, etc. The main feature is a shovel, and the method of suspending it from a derrick and operating it by the ship's winch controlled by two men It is lowered into the hold, tipped sufficiently to give it a grip, and by an ingenious and simple arrangement it is made to fill itself gently and without damage to the coal.

* The writer regrets that the description of this later improvement is rather obscure, but he has not been able to obtain a more accurate one.

The full shovel is now hoisted and swung out and emptied as required. No handling is necessary, all the movements being under the control of the men at the winch. As stated, the ordinary ship's winch will do, but a special winch better adapted for the work can be supplied with the apparatus. Figs. 75 and 76 give an elevation and plan of a vessel fitted with this appliance.

The shovels are of special construction and are actuated by a wire rope which is led from a barrel on one of the winches over lead-blocks down through a pipe in the deck at the back of the winch barrel, and from there the rope is led over suitable blocks to any required spot at the sides of the vessel in the hold, or on to the beams of the bulkheads, and at last shackled on to the shovel.

When stress is brought to bear on this rope the shovel is moved along on top of the cargo and digs itself down. If it should dig too deeply and stop, that is, if the stress in the wire rope is not sufficient to fill the shovel, the stress is kept on the rope and, in addition, sufficient stress is put on the rope for lifting the shovel. The result from these two stresses in different directions is that the shovel will act exactly on the same principle as a steam shovel on a crane or as a hand shovel manipulated by a man.

The most effective work is thus done by the movement of this big steam shovel, and as it digs its way down through the cargo, a hollow is naturally made into which the cargo slides down from all sides. The shovel reaches the bottom of the hold right under the hatch, and all the remaining cargo which is then lying in sloping heaps against the sides of the vessel and against the bulkheads, is then also mechanically taken by the shovel itself as it is hove in towards the cargo wherever the same may be placed.

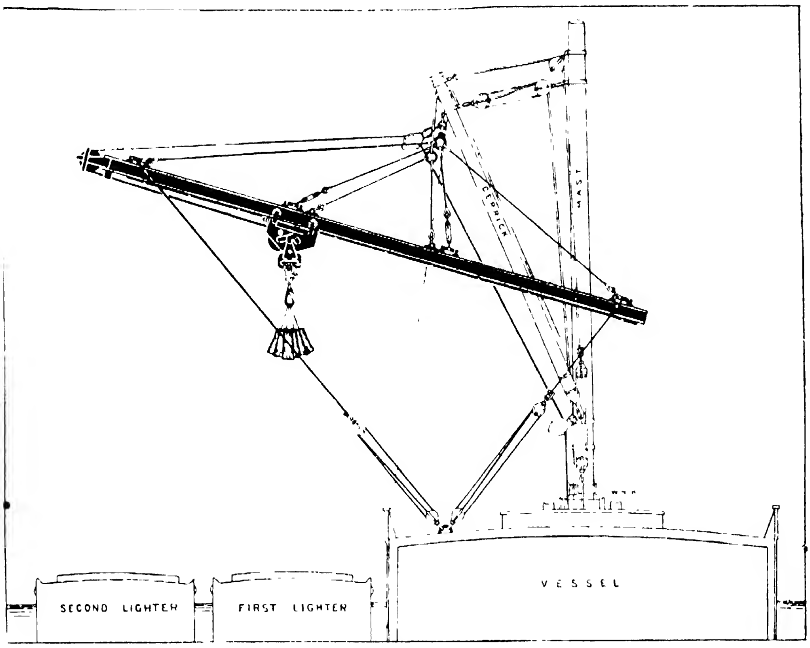


PLATE I

FIG 74 METHOD OF SUSPENDING TEMPORARILY TRANSPORTER FROM THE RIGGING OF A SHIP

The shovel does its work so well that scarcely any hand trimming is necessary, and there will really be so very little cargo left that it practically only amounts to "sweepings."

This plant can be applied to any existing craft at a comparatively trifling cost, and it can easily be stowed away when out of use. One vessel fitted with the Sieurin gear discharged 4,000 tons in 20 hours at a cost of only 1½d. per ton for labour. Usually each shovel has a capacity of 30 cwts, and can be discharged at the rate of 40 tons per hour. One of the latest installations on this system is that on the Danish steamer *Avanti*. The English agents for the machine are Messrs Clarke, Chapman & Co, Ltd., of Gateshead-on-Tyne.

Among the automatic mechanical methods of bunkering we must consider first the Doxford Mechanically Equipped Steam Colliers made by Messrs William Doxford & Sons, Ltd., of Sunderland. The detail of the hull of such craft does not interest us here except for the mechanical installation it conceals. The centre portion of the bottom of the holds between the bilge ballast tanks is fitted with a tunnel having a sloping roof and giving free access to two conveyers. The inclined bilge slopes from a hopper at each side of the tunnel, so that the whole of the cargo can gravitate to a series of outlets leading to the two conveyers in the tunnel. These conveyers are of the Doxford patent type,* consisting in the main of two endless wire ropes connected transversely by axles with runner wheels, the axles being clamped to the ropes by steel blocks. The axles also carry pressed steel trays forming a continuous receptacle for holding the coal. The wheels run on angle rails, and the working and return strands are closer together than is usually the practice with conveyers. Owing to the use of wire ropes, the terminal pulleys have to be comparatively large, which is also essential for the easy curve which the conveyers describe when approaching the terminals, which would not be possible if the conveyers had to be kept very taut, as the weight of the conveyer will assist in obtaining the necessary grip on the driving terminal.

The conveyers work generally in the direction from stern to bow, at which latter end the conveyers rise sufficiently to discharge their loads on to a second conveyer or pair of conveyers which elevate the coal to the necessary height to suit the conditions under which the vessel has to deliver its cargo. There is no apparent reason why the conveyers should not run fore and aft with the elevator in the poop. In cases, for instance, where it is intended to deliver into barges alongside, the secondary conveyers need only reach above the deck level by a few yards, or for delivery on to a wharf a shore gear can be installed to receive the cargo direct from the primary conveyers, and so make the secondary elevators unnecessary. On the other hand, if the collier is intended to deliver coal into bunkers of other ships, the secondary conveyers will be very tall and resemble more the elevator than the conveyer.

The cargo is fed into the primary conveyers by way of drop feed doors 34 ins. by 24 ins. spaced at regular intervals along the hold on each side, the spaces between these doors being occupied by V-shaped hoods, which give access to each door from the tunnel, and together with the transverse incline of the tunnel and tanks form an automatic feed. The doors are opened by the operator in the tunnel in succession, but in no case must more than one door be open at a time, as the size of the doors is so chosen to admit just as much coal as the conveyer will carry. The man stands by, and if the flow of the coal should be checked by an extra large lump blocking the outlet, he removes it by means of a hook or pinch bar provided for the purpose. This, however, but rarely happens except when large Scotch, Yorkshire or Welsh coal is handled, in which case a special

* The earliest installations were fitted with composite cotton and rubber belts

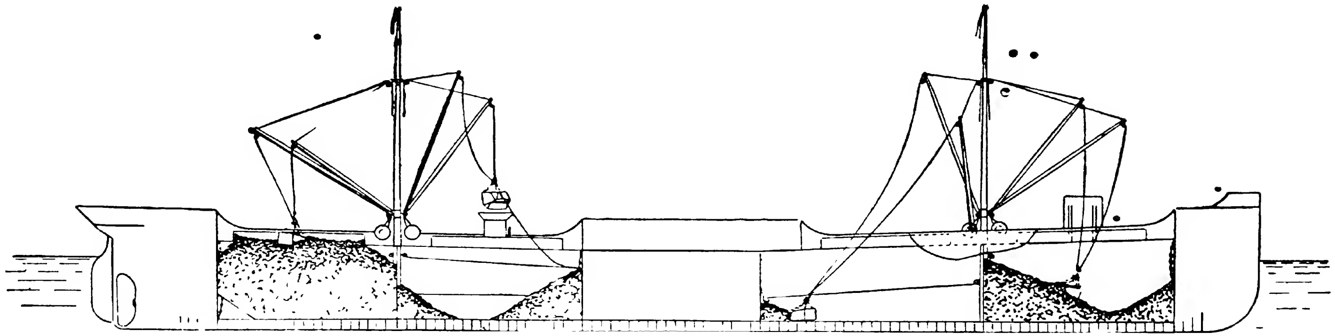


FIG. 75.—COLLIER FITTED WITH SIEURIN WINCHES AND STEAM SHOVELS

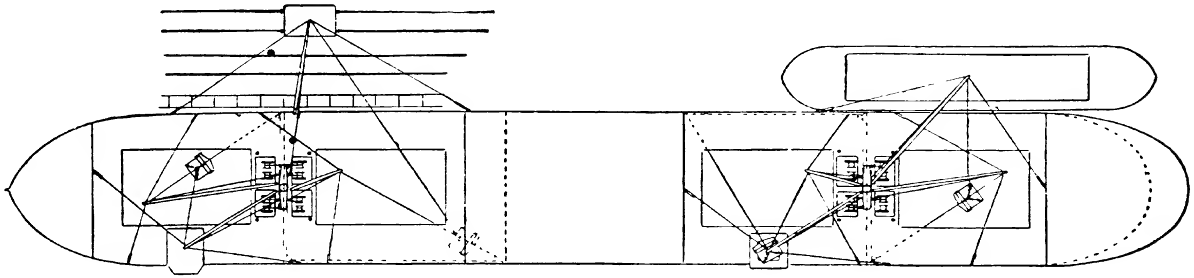


FIG. 76.—PLAN OF FIG. 75.

slide door is fitted in each hood to supplement the aperture of the drop door This slide door is only used as a means of relieving stoppages and by no means as a permanent increase in the size of the outlet. Where the cargo consists of large Welsh coal, it may be expedient to employ two men on each conveyer

The amount of coal which will pass one door varies from 200 to 400 tons per hour. This variation is due to occasional stoppages and the slower flow of large coal. The higher figure is for small coal. As the two conveyers work simultaneously, the capacity of such a collier will be from 400 to 800 tons per hour.

According to Messrs Doxford, the capacity of the collier with different coal varies as shewn in the table which is given below, with outlets 34 ins. by 24 ins

The drive for the conveyers is by gear from a compound surface condensing high pressure engine Clutches are provided so that each or both conveyers, with the full load on, can be instantly stopped or started by the officer on deck

Delivery shoots are fitted on both sides of the oblique elevator, which can be lifted or lowered by hand winches to suit the height of the vessel alongside. A controlling door at the

District	Description of Coal	Tons per Hour	Tons ex Ship
Durham	Wearmouth Gas	400	800
"	Hetton Duff	400	800
	Hetton Double Screened Nuts*	400	800
"	South Hetton Unscreened Steam	400	800
Northumberland	Cowpen West Hartley Steam	350	700
Yorkshire	Brodsworth Main Best Hard Steam	250	500
Scotch	Arniston First Class "Cannel"	250	500
Welsh	Ferndale Large Steam	200	400
"	Lewis Merthyr Steam (Admiralty)	200	400
"	"Viponds" Large Steam	200	400

* In this case Retarders were used

end of each shoot, manipulated from the deck by the same operator, serves to distribute the coal to the ships and prevent at the same time any rush of coal, thus avoiding breakage.

The staff of a vessel so fitted consists of 7 hands:

1 Fireman,
1 Engineer,
1 Greaser (part of the time),
2 Labourers in the tunnel, and
2 Labourers on deck to attend to clearing up the holds after the cargo is run out.

The cost of delivering coal, including labour, fuel, and oil does not exceed ¼d. per ton, if conditions are favourable and with a trained staff In addition to the obvious advantages of this system, there is one of great importance, namely, that weather conditions do not affect this form of coal supply, as in rough weather the ordinary big shore gang will not work.

The application of the Doxford system extends to quite a variety of types, all of which reduce the cost of coaling and minimise the employment of unskilled labour. The original type of the Doxford steam collier is fitted with two primary conveyers in the tunnel, running fore and aft, which transfer their load to one or two secondary conveyers in an inclined position, reaching only a few yards over the deck, to give delivery of the cargo overboard into lighters or barges, or on shore. A very fine example of this type is the s.s. *Herman Sauber* (see Fig 77), 315 ft long by 49¾ ft. beam by 24 ft draught, with a speed of 10 knots and a capacity of 3,700 tons She has nine hatches each 33 ft. wide, 11 ft fore and aft, and 30 sliding doors, so that 75 per cent. of the cargo runs on to the conveyers without hand-work. She transferred 800 tons per hour of Durham coal with six men at the trial The cost of discharging an ordinary collier of the same size would be £112, the number of men required would be 110, and under favourable conditions this would take 11 hours. The discharge of the *Herman Sauber* during a trial cost £12, the time occupied was 6 to 8 hours, and it took 7 men, but even this comparatively low figure is too

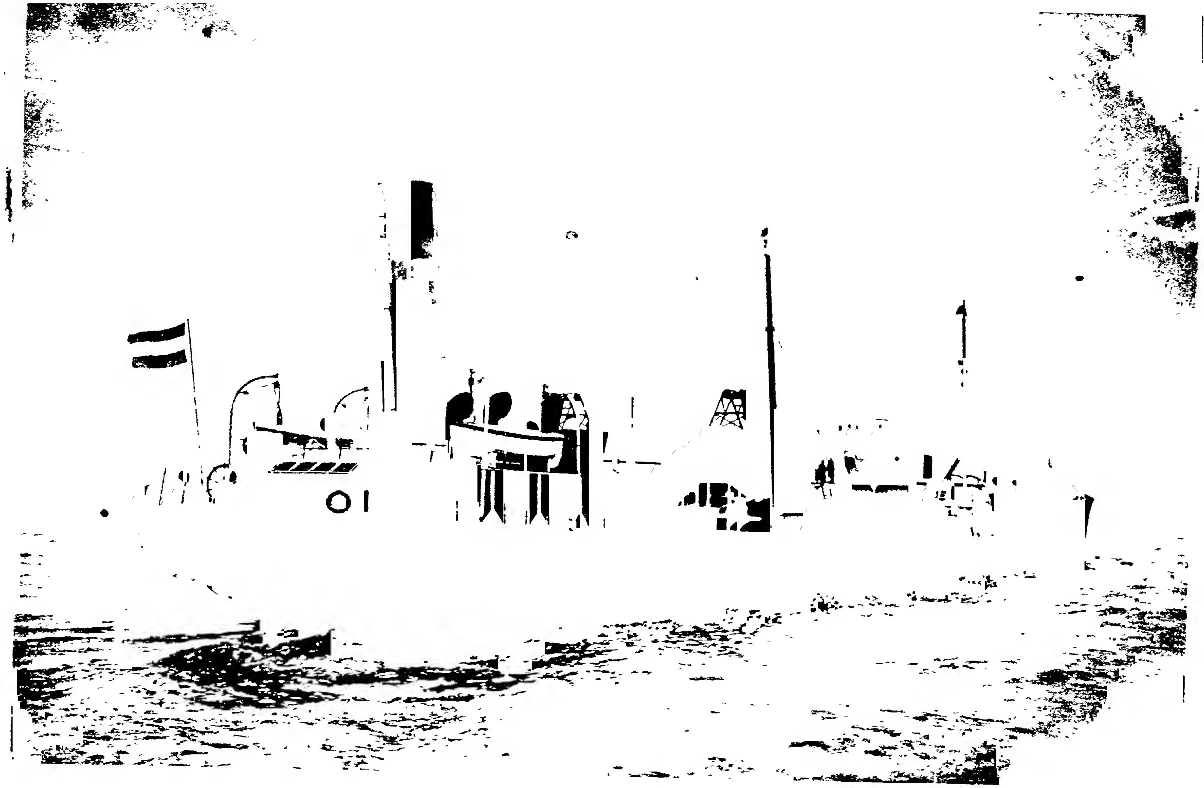


FIG. 77.—DOXFORD STEAM COLLIER "HERMAN SAUBER"

high, as the test took place under adverse conditions and with inexperienced men.

In the next type the secondary conveyer or conveyers are replaced by bucket elevators of a height sufficient for "overall delivery," *i.e.*, right over all side obstructions to midship, or by branch shoots for side-port coaling. One of the best examples of this type is the coaling vessel, *Portrush*, which has two elevators, not one, as usual. The capacity is 725 tons and the maximum rate of discharge 250 tons per hour.

The next development is one of great importance. At a casual glance it must appear even to the uninitiated that it is a wrong policy to employ an expensively fitted vessel for the purpose of travelling backward and forward for coal, work which can be done equally as well by any other steam craft not fitted with those labour-saving equipments. In following this policy, the amount of coal transferred cannot possibly work out as economically as if the apparatus could be used exclusively and constantly for loading coal only. It suggests itself, therefore, to divide such floating loading devices into two parts, somewhat like a locomotive engine and its tender. Messrs. Doxford, in following this theory, have in the first instance built the primary conveyer into one craft and the secondary conveyer, or rather elevator, into another. Thus the elevator can be placed in position alongside the ship to be coaled, whilst one, or preferably more, attendant barges go back and forth supplying her with coal. The conveyer in the attendant barge generally receives its driving power from the elevator pontoon.

The final development appears to be to eliminate even the expense of the conveyer in the attendant barges, which makes the whole process still more economical. The elevator pontoon is provided with a snug berth for the ordinary coal barges and their contents are transferred by grab into it.

It is estimated that 112 men in ordinary colliers discharge at the most 300 tons of coal per hour, or a trifle over 2½ tons per man per hour. With a Doxford collier 600 tons per hour can be discharged by 6 (or with the oiler 7) men, or practically 100 tons per man per hour, so that the employment of one such collier will dispense with more men than would form a company of infantry.

Another type of floating coal loader is that manufactured by A. F. Smulders, Werf Gusto, Schiedam, Holland (London Agent: Anderson, Rodger, 38, Victoria Street, Westminster, S.W.). The conveying element in these coaling vessels deserves rather the name elevator than conveyer. It is not, so to speak, a hybrid of the two, and perhaps the term "amphibious" may be permitted to express its functions, as it works under water and yet out of it equally well. We have seen that in the Doxford system there were primary and secondary conveyers. This is not so here, the same conveyer which receives the coal automatically through a great number of sliding doors from the hold of the vessel ascends when reaching the bow of the craft and so acts as an elevator. The traction element is chains instead of ropes. The difference most apparent to the beholder between the two types is that by virtue of the combined use of the same mechanical appliance for conveying and elevating the coal up an incline of 45° necessitates a great steelwork structure overhanging the bow, see Fig. 78. With the Doxford unloader the inclined elevator is turned in the opposite direction, *i.e.*, reaching from either extremity of the ship to its middle.

Steamships for the coal and ore traffic on the Great American Lakes have also lately been equipped with double hopper bottoms and two conveyers which deliver to a third central conveyer for raising the load from the two primary conveyers up an incline of about 20° to a sufficient height from where it may be conveyed ashore by a fourth conveyer, this time a belt conveyer. The general arrangement

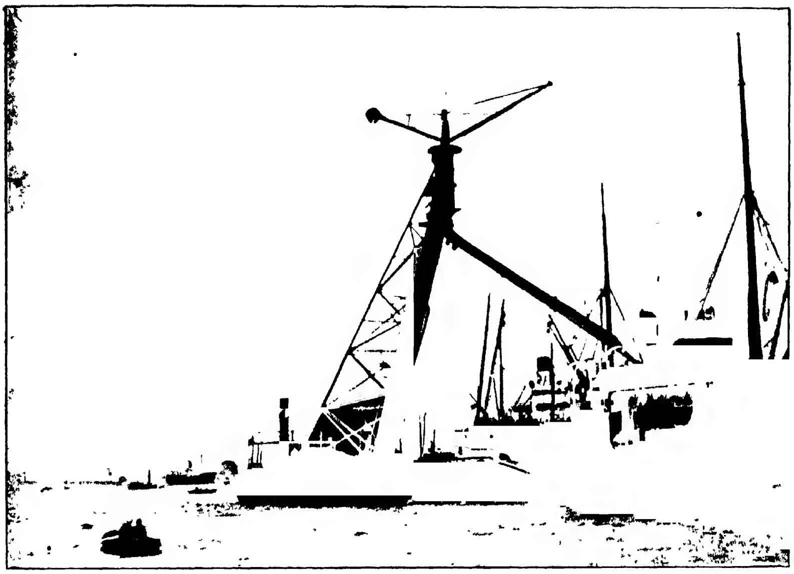


FIG. 78 SMULDERS' STEAM COLLIER

is precisely similar to the Doxford colliers. Vessels owned by the Michigan Alkali Company, Wyandotte, were equipped with the conveying machinery by The Stephens & Adamson Company of Aurora. The length of the latest is 370 ft., and the cargo capacity 5,600 tons. The engines and boilers are at the stern, and the deck consists largely of hatchway openings extending nearly the full width of the deck.

Under each of the two rows of hoppers runs a longitudinal pan conveyer 3 ft. wide, consisting of a continuous series of steel pans 36 in. wide by 24 in. long by 20 in. deep. The cross spindles forming the link-hinges are 24 in. pitch. Each of these spindles is provided with two 6 in. flanged runner wheels 3 in. wide on the tread, which run on steel bars for rails. The terminal in the bow is driven by an independent engine. This end of the conveyer follows an ascent of 30°, so that the pans of both conveyers can discharge into the feeding terminal of the third conveyer, which is in this case an inclined band conveyer 42 in. wide which rises above the deck, its upper end being supported by a steel structure. Beneath the upper terminal of the third conveyer is the turntable of a revolving boom or jib 100 ft. long, upon which another band conveyer runs which receives the load, and by virtue of its flexibility facilitates the final delivery in any direction. The end of the jib is supported by tackle from a short steel mast. The speed of the pan conveyers is about 60 ft. per minute, while that of the band conveyers is about 350 ft. per minute. The same conveyer company have fitted similar vessels with slight variations from the above. The cargo is discharged at the rate of 600 to 900 tons per hour.*

There are quite a variety of other types, but we will confine ourselves to a few words concerning the mechanical coaling barge *Herald* of the L. & N.W. Railway at Holyhead on the "Holland" system. She has a capacity of 400 tons, and is fitted with two elevators, but, unlike the three previous types, without a conveyer.

* For a fuller description see *Engineering* of October 19, 1911, and *The Engineer* of December 31, 1915.

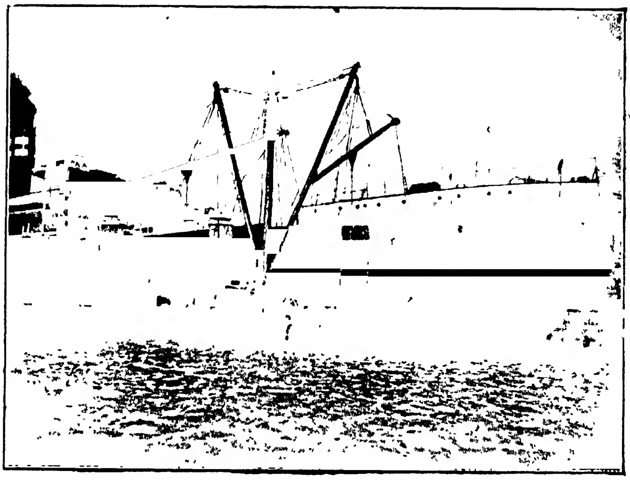


FIG 79.—TWO TEMPERLEY TRANSPORTERS LOADING COAL AT BARCELONA

Each of the elevators handles 100 tons per hour, so that the whole cargo can be transferred to the bunkers of a steamer in two hours. The two elevators rest obliquely in a central channel lengthwise of the vessel at an angle of about 45°. This channel is open at the top and commands the whole of the two ranges of bunker compartments one at each side of this passage. The elevators are portable and can be placed in turn so as to communicate consecutively with the various outlets of the bunkers. As soon as one of the elevators has emptied one bunker, it is shifted to the next outlet, and so on. The elevators reach above the deck just sufficiently high to get an easy fall to the bunkers of the L. & N.W. Railway Co.'s boats. Both elevators and shoots are completely enclosed, and some of the exhaust steam from the engine is conducted into the top terminal of the elevators to prevent dust. The crew consists of seven men only

Of more or less self-trimming colliers for broadside coaling fitted with cranes and winches, there are many, and a few typical ones can only be mentioned here. There is the *Elenor*, on the Ayre-Ballard Arch principle. The *Sheaf Arrow*, capacity 3,100 tons, has eight steam winches, eight derricks and gaffs and Admiralty spar gear. She has been specially designed to meet the requirements of ships coaling the Fleet. The *Ellerbeck* and the *Transporter*, of the Blyth Shipbuilding and Dry Docks Co, Ltd., are both fitted with derricks and gaffs, two derricks and one gaff to each hatch, with two steam winches. The *Rouen*, of Irvine's Shipbuilding & Dry Docks Co., Ltd, West Hartlepool, and *Sir Richard Awdry*, by the Clyde Shipbuilding and Engineering Co., Ltd., Port Glasgow, are fitted with eight Temperley Transporters

Sir William Arrol & Co, Ltd., have fitted quite a number of similar craft with Temperley Transporters for broadside coaling of war vessels and merchant steamers. With their vast experience they have had a unique opportunity of designing the best vessel for the Temperley. The largest of such vessels we know of will hold 12,000 tons of coal, and 600 tons of bagged coal per hour can be handled with the plant. These vessels are self-propelling. An example of a smaller vessel is given in Fig. 79. It is fitted with two Temperleys and two hoppers resting on a telescopic framework, so that the

hoppers can be adjusted to fit the side bunkering ports of the vessel to be coaled. When thus adjusted the Temperley grabs the coal out of the hold and drops it via the hopper, as with a funnel, into the bunkers of the ship. It seems extraordinary that our own navy possesses only one collier, the *Mercedes*, of 9,900 tons capacity, and employs generally private colliers.

The United States naval colliers, *Jason*, *Orion*, and *Neptune* (see Figs 80

with marine cableways could transfer to a cruiser 500 tons of coal in the daylight hours, steaming at 10 to 12 knots while doing so.

Porhydrometers have been fitted to many colliers to ascertain the weight of their cargo, and these might, under certain circumstances, dispense with the automatic weighing of the coal as it leaves the collier, as the reading of the instrument before and after coaling will give the amount supplied.

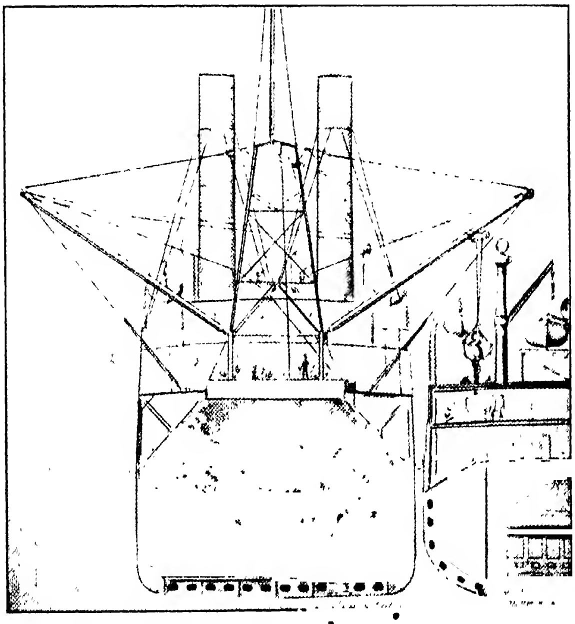


FIG. 80—MARINE TRANSFER ON THE UNITED STATES COLLIERS "JASON," "ORION," AND "NEPTUNE"

and 81) have a capacity of about 10,000 tons each, and the coal is transferred by the Spencer Miller system (which somewhat resembles the appliance known to us as the Temperley Transporter) by 24 derricks and a like number of winches. These huge colliers, with their high-speed broadside coaling gear, can coal three ships per day when the sea is smooth. When the sea is moderate, but not rough, each collier equipped

The broadside coaling of the U.S.S. *Wyoming* (taken from a paper by Spencer Miller) took place at Guantanamo Bay in the spring of 1914. The *Jason* used her eight booms continuously, dropping coal at eight different points along the deck and through the shoots of the *Wyoming*. The *Nereus* used six to eight booms intermittently on account of breakages.

All was made ready for the test the night before—time to get ready not

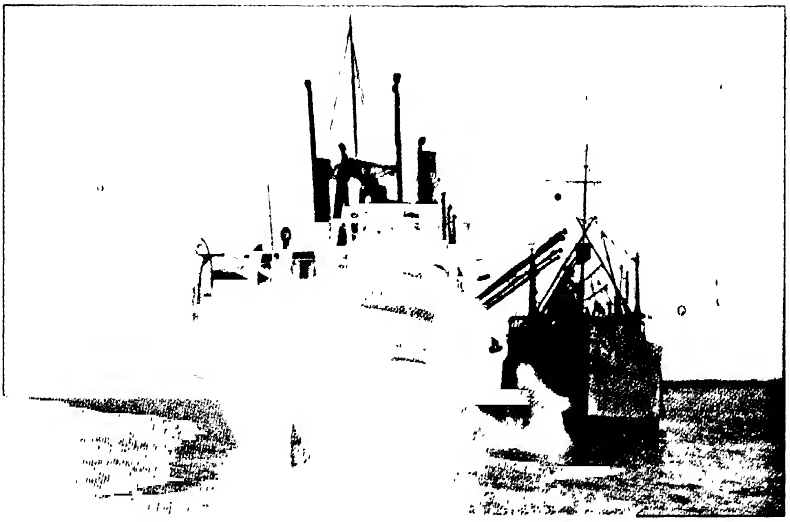


FIG. 81.—THE U.S.S. "JASON" COALING U.S.S. "MARS."

given (usually 20 to 30 minutes work on the *Jason*). Coaling began at 5.30 in the morning. Coaling stopped at 8 o'clock for breakfast. Coaling resumed at 8.30. The *Jason* cast off at 9.30 o'clock, after delivering to the *Wyoming* a maximum of 465 tons per hour. The *Nereus* delivered to the *Wyoming* a maximum of 433 tons per hour. The *Jason* delivered a total of 1,040 tons in three working hours, an average of 346 tons per hour. The *Nereus* delivered a total of 1,020 in 3½ working hours, an average of 292 tons per hour. From 550 to 600 tons of coal were heaped on board when the colliers left, and it required from 9 o'clock in the morning to 4.30 in the afternoon to clear up and stow the coal left on board. The whole operation of taking on and stowing 2,060 tons of coal was accomplished in 9½ hours, an average of 217 tons per hour. Both the *Jason* and the *Nereus* coaling gears are able easily to discharge 100 tons of coal per hatch per hour. In the official trial of the collier *Jason* 137½ tons of coal were actually discharged in one hour with one operator. At the conclusion of the trial Admiral Badger expressed the opinion that the *Wyoming* could at any time take on 2,100 tons of coal in five hours from two colliers in smooth waters, stowing the surplus left on deck at leisure. From the above it appears that from one collier the taking on and stowing of 2,100 tons of coal would require approximately 10 hours, being an average of 210 tons per hour. The coaling rate in 1914 is, therefore, seven times faster than it was in 1893.

The U.S.A. Navy own a fleet of 13 large colliers, more or less after this type, fitted for coal and oil fuel, as well as 11 older and smaller ones.

The American method of piling coal on the decks of battleships and clearing it into the bunkers afterwards is not approved of in our navy, and we coal only as fast as the fuel can be stowed away, *i.e.*, 100 tons per hour.

Broadside coaling is very well in fine weather in harbours and sheltered bays, but dangerous or impracticable on the high seas, and as it is impossible to choose a favourable day when refueling warships becomes imperative, the only methods are the end-on coaling by cableways, and to transfer

coal from a collier to a battleship under way on the high seas while one vessel is in tow of the other. Let us first realise the importance of this process.

IMPORTANCE OF COALING UNDER WAY.

Bunkering is necessary every 7 to 15 days, according to the size of the ship, and when blockading sometimes 10 to 25 per cent. of the ships may be absent at some base replenishing their bunkers, and it may take several days to get to that base, coal, and return, not to mention the coal which is consumed during the journey. Ships must, therefore, either coal at sea or when submarines are present. Safety from submarine attack also necessitates constant change in direction of progress. Now these movements do not affect the coaling by the marine cableway, while they make broadside coaling practically impossible The Japanese battleship *Hizen* (formerly the Russian battleship *Retvizan*), which is fitted with the Spencer Miller marine cableway, anchored in the roads at Honolulu in October, 1914, awaiting the exit of the German cruiser *Geier*, and as she arrived there with her bunkers full and being 14 days out of Yokosuka, her nearest naval depot, she must have coaled on the way with her marine cableway installation.

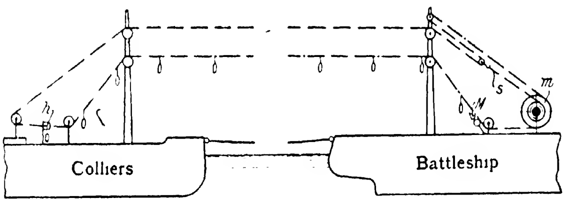


FIG 82 —DIAGRAM OF ADAM SYSTEM FOR COALING SHIPS UNDER WAY

leave the blockade for the smooth waters of home ports for re-fueling. With 100 ships on blockade duty burning 50 tons per day, they should be rebunkered every ten days, so that 10 per cent will always be absent. Every time a cruiser retires from the patrolling line the blockade is weakened, to say nothing of the danger of attacks by submarines which lie in wait on the route to and from the coaling base. The *Good Hope* and *Monmouth* revealed their position to the Germans by entering a harbour for coal and were sunk later by them. In the Japanese blockade in 1904 Togo in his blockade of the Russians at Vladivostock failed because the Japanese were unable to coal their ships at sea.

The safest place to re-fuel is on the high seas going at a speed of, say, 10 to 12 knots, and this is just a safe speed at which it is necessary to move

The marine cableway has been experimented with by every navy of any note, and a good many of the Russian ships carried the gear during the Japanese War The Lidgerwood Manufacturing Company fitted the Russian battleship *Retvizan* (now the *Hizen*) with an experimental plant on the Spencer Miller system, which was so satisfactory that ten of the largest battleships of the Baltic Fleet were also so fitted. When coaling, the vessels are 300 ft. apart in a smooth sea and 800 ft. in a rough sea The American naval authorities experimented extensively with the same system, but improved, as late as April, 1913, with very satisfactory results, the maximum speed of the conveying cable being 3,000 ft. per minute. Our own naval authorities have experimented for years with a variety of plant on the Spencer Miller

system made by Messrs. Temperley, which did good work under favourable conditions. In rough weather, however, when the compensation gear which keeps the cable uniformly taut becomes overstrained, it heats up to such an extent that it becomes useless. The latest Lidgerwood-Miller Marine Cableway has a compensating gear (which will be described later on) on an entirely different principle, which makes such occurrences quite impossible. This system for coaling at sea has been adopted by the United States and Japanese Navies.

To-day the two surviving systems out of many attempts for coaling at sea are, the reciprocating cableway (Lidgerwood-Miller Marine Cableway), and a continuous or endless rope apparatus (the Adam Endless Rope Coaling-at-Sea Gear) used by the German Navy. The systems are briefly as follows:—

The Spencer-Miller consists of a cable which runs at a high speed backward and forward, taking a bundle of sacks holding 700 to 800 lbs. each journey, transporting about 80 tons per hour. When the vessels, collier and battleship, are 300 ft. apart, it takes from 50 to 60 seconds for the double journey.*

The Adam system is that in which an endless cable is always running in the same direction instead of backward and forward. The earlier form had the cable high up from the mast of one vessel to that of the other, and instead of being kept taut by an ingenious winch which will keep the cable in the same condition of tightness whatever the distance apart of the craft, as in the Spencer-Miller system, the endless cable is here kept taut by passing (at the collier end) over a series of rollers up and down, like over a pair of multiple blocks. The lower set of these pulleys carries a heavy weight, which is raised as the ships separate further and is lowered when they approach nearer. The working of this system is continuous, but the loads are smaller and the speed of travel slower than the Spencer Miller system

The tightening arrangement just described has been modified by Leue, who has in the place of the weight a cylinder and plunger with compressed air, one set of sheaves being placed on the piston and the other set on the cylinder, similar to those on a hydraulic lift. (The British Admiralty experimented with and discarded a similar device operated by steam.)

The Adam system, as now perfected, brings the endless cable from the two masts down to the deck of the two ships at the terminals, which facilitates the hanging on and taking off of the sacks of coal. The diagram, Fig. 82, shows the essential parts. At the terminal on the battleship the endless rope is forced to prescribe a bight or loop by two additional sheaves, and from this surplus portion of the cable the difference in the distance from craft to craft is made good. The snatchblock S forming the bight is connected to a winding drum *m* with electrical equipment, which will keep the rope taut, but if the tension exceeds certain limits it will pay out rope, while it will wind up rope whenever the conveyer cable shows a tendency to become slack. The coal sacks are attached to the cable at *h*. Here the endless cable passes through a conical sleeve fixed to the deck of the collier, and each sack is fixed by a sling loop of strong cord about a yard long. As soon as this is adjusted over the sleeve, it is pushed off the cone on to the cable, the weight of the sack immediately tightening the sling loop on the cable. The two sheaves on the masts which the sacks have to negotiate are set sufficiently obliquely for the sacks to pass uninterruptedly. At M is a fixed knife which cuts the strings as the cable passes and releases the sacks, which fall on to the deck of the battleship. The capacity of this cableway is from

* A fuller description will be found in Mr Spencer Miller's paper read before the Society of Naval Architects and Marine Engineers, Vol 22, 1914, which was fully reported in *Engineering* of January 15 and 22, 1915.

50 to 60 tons per hour in a moderate sea.

The German naval authorities have adopted the Adam system after an expenditure of over £75,000 on experiments, but information as to how many ships have been so fitted is not obtainable.

OIL-FUEL BUNKERING AT SEA.

Without discussing the merits or otherwise of oil-fuel, its employment has the decided advantage that it can be bunkered comparatively easily. The United States Navy have designed their battleships for the last five years exclusively for oil-fuel, and our own battleships of the *Queen Elizabeth* type are also so fitted. In one harbour in the Caribbean outside of the Canal Zone a stock of 10,000 tons of oil-fuel is permanently maintained by the United States, an amount about sufficient for the supply of a division of oil-burning battleships of the *Arizona* type.

It has been suggested in America that the oil should be bunkered by the marine cableway, like coal, and that it should be taken over in tanks holding a ton, but as it is much easier to have a hose communication between the vessels, which need not be high up out of the reach of the water like the coaling cable, but can be low down, the idea has never been exploited. The British Admiralty, says Mr. Spencer Miller,* have mastered the art of oil-bunkering at sea and the apparatus is carried on their own oil tank ships.

The following is gathered from Mr. Spencer Miller, the pioneer with twenty years' experience with the marine cableway.

The British Admiralty require a towing speed of at least 10 knots while re-fueling at sea. They coaled at sea in 1906 at a speed of 11 knots. The British Admiralty's tank steamer *Petrolium* transhipped oil at sea at towing speeds above 12 knots. The method they employ is practicable when the sea is smooth, and is illustrated in Fig. 83. *Shipping Illustrated*, November 2nd, 1912, says:—"The operation of bunkering at sea while steaming at a rapid rate is regularly carried out by way of training. . . . Other nations have now adopted this method, which is very effective, but needs great care in seamanship and no little practice."

The British battleships tow the oil-tank ship. One hawser tows, and a secondary line supports the oil-hose by hangers at frequent intervals. This plan was tested by United States ships with a small hose. The tank steamer *Petrolium* carries 900 ft. of 5 in. diameter flexible bronze hose, weighing 9 lbs. to the lineal foot, a total of 8,100 lbs. The distance between ships is about 600 ft. The greater portion of the hose drags in loops in the sea (see Fig. 83), and this results in longitudinal strains which tend to damage the hose. The loops are also apt to gather down against the bow of the towed ship, which affects the towing, and they form sharp bends which may shorten the life of the hose. Eighty tons of oil per hour are thus transhipped. The United States Trial Board, testing this method between the fuel ship *Arethusa* and the destroyer *Warrington*, used a 2½ in. hose. They reported the difficulties substantially as mentioned above.

Fig. 84 indicates diagrammatically an improved arrangement for supporting the oil-hose while transhipping oil at sea. The same sized automatic tension engine and carrying cable used in the marine cableway are required for a proper support of the oil-hose free of the sea. An oil-hose supported in this manner permits oil-bunkering to be carried on in heavy seas. The automatic tension engine furnishes the necessary elastic medium for paying out and taking in the supporting cable as demanded by the motion of the ships. It maintains a uniform tension on the supporting line, and prevents any lashing or whipping of the hose while the operation is being carried on in a heavy sea. The weight of the 5 in. metal hose

* In a paper read before the Society of Naval Architects and Marine Engineers, Vol. 22, 1914.

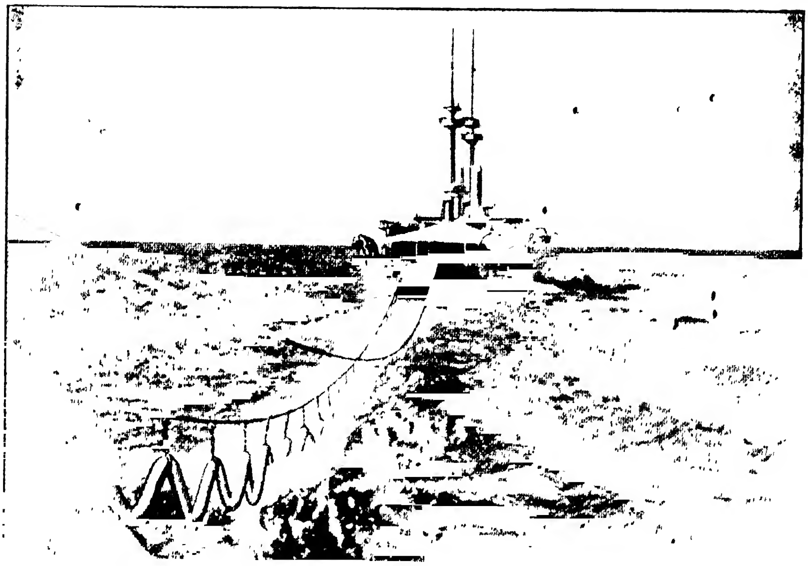


FIG. 83.—BRITISH METHOD OF OIL-BUNKERING AT SEA

and the oil to be supported by the suspended cable is double the weight of the carriage and coal-bags of the marine cableway. The necessary tension in the supporting line would be the same in both instances. The oil-hose is a uniformly distributed load; the bags of coal a concentrated load frequently in the centre of the span.

The automatic tension engine now installed on the collier *Cyclops* will develop a tension of 18,000 lbs., and will sustain a 5 in. flexible bronze hose and a 1 in. diameter steel wire rope on a span of 600 ft. with a deflection of about 58 ft. The rear mast of the *Cyclops*, with its heavy pulley block secured to the mast-head for coaling at sea, is needed for oil-bunkering at sea. The collier *Cyclops* carries oil-fuel and coal. Many of the United States battleships burn both kinds of fuel. The *Cyclops* can deliver either fuel if provided with a suitable oil-hose, reel, and oil-pumps. Oil-bunkering at sea by this method can be carried on in a heavy sea, the time required for setting up and taking down the hose would be reduced, and all damaging strains in the line minimised.

The Automatic Tension Engine.—The latest type of tension engine in use with the Lidgerwood marine cableway

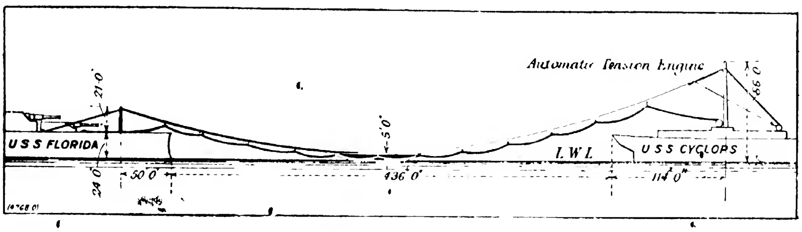


FIG. 84.—SPENCER MILLER METHOD OF OIL-BUNKERING AT SEA

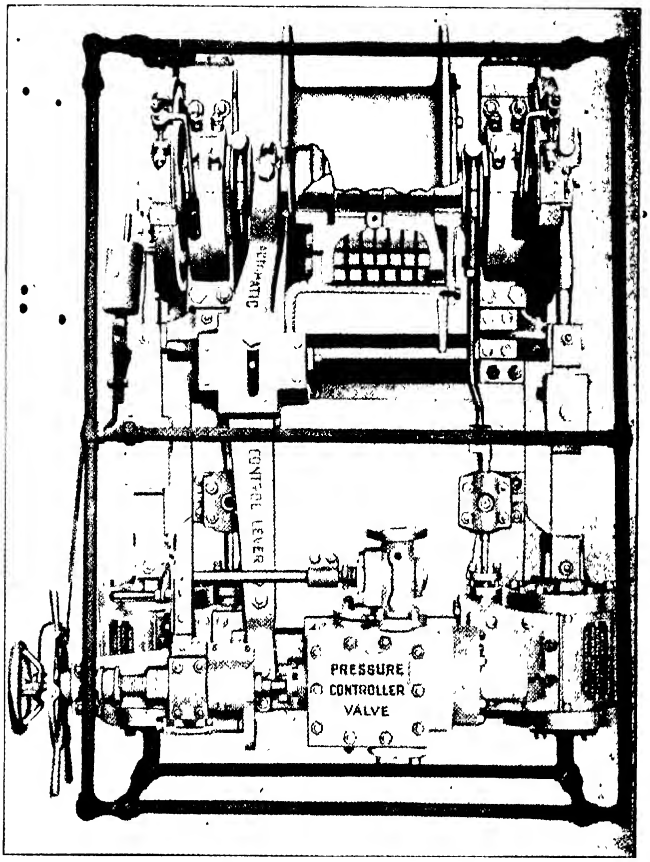


FIG 85 -CROSS SECTION OF SPRING DRUM OF SMALL AUTOMATIC TENSION ENGINE, SHOWING LEVER CONNECTIONS BETWEEN DRUM AND PRESSURE CONTROLLER VALVE

and liquid fuel bunkering plant is a self-contained unit. It has two steam cylinders driving a common crankshaft. A pinion on the crankshaft drives a gear firmly keyed to the drum spindle. The drum is connected to the drum spindle by huge coil springs, allowing a limited rotation of the drum on its spindle. Any change in tension in the rope causes the drum to rotate slightly on its spindle, and this motion is utilised to operate the controlling valve which increases or lowers the steam pressure correspondingly. This spring-drum construction, therefore, is a feeler or detector of tension changes. The steam for operating the engine is introduced into the cylinders through a novel form of controlling valve. This valve regulates the amount and pressure of the steam supplied to the cylinders. A coarse thread is cut on the hub of the drum (see Fig. 85) The drum itself forms a running nut on the hub, so that the limited rotation of the drum on its spindle, or rather upon its hub, will cause a slight lateral motion of the drum. This movement is transmitted by a lever connection between the drum and the steam valve in such a way that the steam supplied to the cylinders bears

a definite relation to the tension in the cable.

Fig. 85 illustrates a small automatic tension engine. It shows part of the drum in section, revealing the volute springs and on the left-hand side the thread on the hub, together with the control lever reaching right down to the pressure-control valve. A slight increase in the tension of the cable produces a reduction of the steam pressure, permitting the rope to overhaul the engine and restore the tension to normal. A reduction of tension produces an increase of steam pressure, again causing the engine to act as a take-up to restore the tension to normal. The tension developed by this engine in pulling in is slightly less than the resistance set up in the cable to overhauling, but for all practical purposes the tension is uniform and constant. Experiments at the testing-station have been made in an endeavour to determine the interval of time between the slackening of the cable and the starting of the engine, but no one has been able to measure the interval. To all intents and purposes it is instantaneous.

In addition to the automatic control, the engine is provided with means for manually regulating the tension by a hand-wheel. If this be moved one way it increases the tension, and in the other way it decreases it. In practice, therefore, after the main cable has been secured to the battleship, the operator turns this wheel by degrees, gradually increasing the working tension of the main cable. An indicator on the engine shows what tension is being maintained at the time.

The automatic tension engine just described is one of the only two devices at present known which can compensate and maintain a uniform tension in the cableways for re-fueling end on under way. The other is the Adam tension winch, which forms the essential portion of the apparatus adopted by Germany. These two appliances perform successfully what the sea anchor failed to do. Piston (be it pneumatic, hydraulic or steam) or weight compensation, with block and fall, have proved to be impracticable, as they do not allow sufficient latitude, which in the opinion of Mr. Spencer Miller should not be less than 200 ft., besides there are other inherent weaknesses, into which we cannot enter.

THE MECHANICAL TRIMMING OF COAL IN THE BUNKERS.

The great saving of human energy which can, as we have seen from the foregoing, be achieved over and over again by judicious capital expenditure, is not by any means limited to the operation of getting on board and into the bunkers of the millions of tons of bunker coal which we annually dispose of, but we can record a further saving by mechanical trimming in the bunkers

From the last Board of Trade Returns (for 1913) we learn that about 24,000,000 tons of coal are annually shipped as bunker coal for navigation purposes, and we shall not be far from the mark to assume that half this amount, say 12,000,000 tons, are put on board by hand at an expense of about 9d. per ton. Using self-trimming colliers and lighters, this can be done at an outside and inclusive cost of 3d. per ton, equal to an annual saving of £300,000; and if mechanical trimming in the bunkers of 50 per cent. of this quantity, or, say 6,000,000 tons, is added a further saving of 2d. per ton can be effected, which gives a total saving of £350,000 per annum. This further saving of £50,000 will be made apparent in the following. But let us first understand that it is not only men we must release; the saving of both men and money is absolutely necessary, for to win this war we want both. Cheapening any process is in substance tantamount to the saving of men who may be better employed, and it is only by the adequate provision of money, or money's worth, that the fighting forces can be efficiently maintained, and in increasing numbers equipped and munitioned.

The bunker capacity of large liners

is from 6,000 to 8,000 tons, and under normal conditions the bunkers are refilled or replenished thirty times per annum. If the usual side bunkering is employed, whether by hand or by mechanically equipped colliers, only about one-half the coal can be deposited by gravity, and if the bunkers are to be charged to their total capacity, the other half of the coal will have to be trimmed, and it usually takes from 80 to 100 men to keep pace with the coaling if there is to be no delay and the ship got ready for sailing at the scheduled time.

Now this trimming can be done by a machine which is capable of throwing the coal to a distance of 50 to 60 ft., and if such machines are placed under the shoots from the coal ports on both sides of the vessel, the bunkers can be completely filled.

The progenitor of this machine was designed by the late M. de Brouwer,

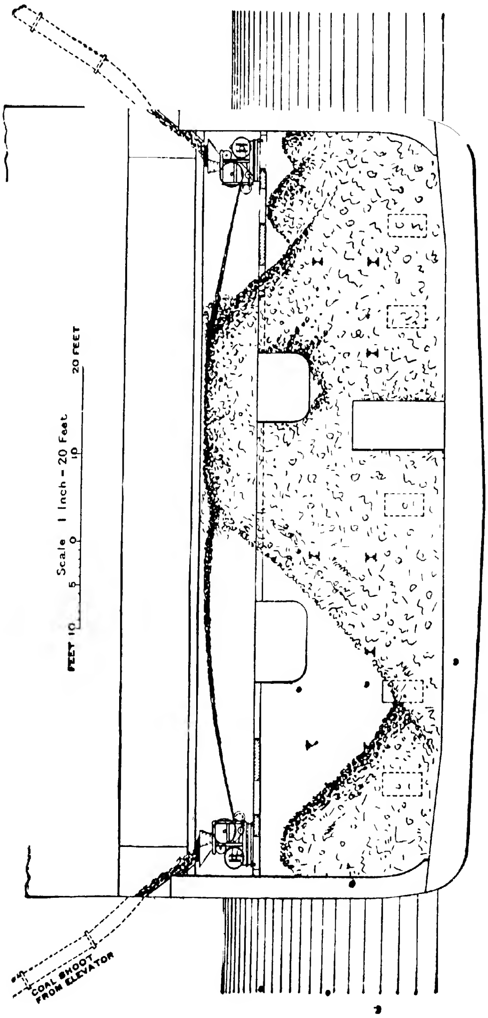


FIG. 86.—ARRANGEMENT OF COAL-BUNKERING MACHINES

of Hot Coke Conveyer fame, and it was first utilised to send a continuous stream of coal into horizontal gas retorts (see Fig. 64). Messrs. W. J. Jenkins & Co., Ltd., of Retford, have exploited this idea, and its marvellous success must be placed to their credit.*

From 20 to 40 such machines are necessary for a large liner, the exact number depending upon the arrangement of the bunkers. If 6 such machines are fed simultaneously, the trimming can be performed in

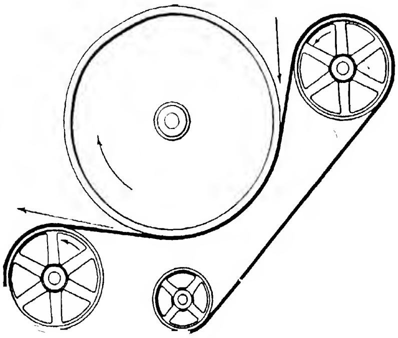


FIG. 87.—DIAGRAM SHOWING PRINCIPLE OF COAL-BUNKERING MACHINE

about 18 hours, and adding to this 18 hours for getting that coal in which requires no trimming, the bunkers can be filled in 36 hours.

The first of these mechanical trimmers were installed on the *Olympic*, of the White Star Line (after an experimental trial on the *Celtic*). The cost of mechanical trimming is 6.5d. per ton, while with hand trimming it is 8.5d. The cost per ton is made up as follows:—

	d.
Power	0.4
Supervision	1.0
Maintenance and depreciation ..	2.1
Drivers, and incidental expenses..	3.0
Total	6.5

* This machine was fully described by Mr. Cecil Walter Ward, Assoc M Inst C E., in a paper contributed to the Institution last year, to whom the author is indebted for some of the particulars.

The outline of the installation is given in Fig. 86.*

We may understand the simple principle on which the machine works best from the diagram, Fig. 87. An endless band is led by three pulleys to describe a certain path, which is further modified by the large drum which is pressed against the band, so that it is caused to revolve with it. This large drum was originally hollowed out on its face to form a channel for the coal, which is ejected with great force in the direction of the arrow on the drawing, but in the present machine it consists of two pulleys each 6 in. wide to leave a clear space of 18 in. for the coal. The steel spindles upon which the drums and rollers are mounted run in roller bearings, the upper guide-roller being supported in adjustable tension-brackets to keep the band taut. The band is 2 ft. 3 in. wide, built up of rubber and canvas to a thickness of $\frac{5}{8}$ in. The motor is of 30 h.p., with a variable speed of 900 to 1,200 revs. per minute, and on account of the dust is totally enclosed. The controller is fixed independently to the bulkhead, and will permit of five speeds of the motor.

The machines run on rails, so that they can be moved out of the way as long as the coal can be lowered by gravity, and the carriages upon which they are mounted are arranged as turntables, to permit a delivery of the coal fore and aft as well as athwart ship.

The hopper of the machine receives the coal direct from the shoot at the side of the vessel, and from here it passes in a vertical direction and parallel with the moving band on which its progress is changed into a horizontal direction. The contact of the coal with the band gives the former the necessary kinetic energy to travel in free flight across the bunker, the speed of the coal being practically the same as that of the band. For mixed coal, large and small, it has been found that a band speed of

* By the courtesy of the Council of the Institution of Civil Engineers.

3,500 ft. per minute is necessary. The space occupied by the machines in the bunkers reduces the capacity of the latter by about 4 tons of coal per machine. The weight of each machine is about 2½ tons, and with its motor 4 tons.

PORTABLE LOADING AND UNLOADING DEVICES.

As the result of two years of war, the scarcity of labour is more felt than ever, and those of the toilers still available are often inefficient and lacking in reliability. Portable loading devices should therefore take a foremost position in all industries where labour must be saved by a modification of the existing *modus operandi*, and where it is difficult or impossible, owing to the present circumstances, to install larger plant. Portable plant is attractive for several reasons. It requires practically no foundations, and is applicable to a greater or lesser degree for the same class of work which is performed by more costly stationary plant, though not quite so economical on account of having to be moved from place to place by hand, but yet the saving effected is so great that it should be installed at once wherever possible.

The storing of coal, ore, and other bulk material in the ordinary way by hand stacking upon unprepared ground, and conversely its reclamation, represents a considerable cost per ton in labour alone, not to mention the great number of men so wastefully employed. Practically every industrial establishment, be it mine, railway, factory, etc., stores some form of loose material in bulk in large or small quantities at various times and places, generally in the open. This material will probably be brought by truck or wagon and is usually stacked by hand, and when the time comes for its removal it is often so replaced in the truck again.

In Fig. 88 a photograph is reproduced which shows a fine lot of fellows (the best raw material for the army), the class of labour used for hand stacking. Such a scene is familiar to everyone who has to deal with railway and dock work. No one can call such an extremely primitive method anything but unsatisfactory, war or no war. It adds the unnecessary expense of from 4d. to 1s., according to circumstances, to the cost of every ton handled, which, moreover, is absolutely a waste expense. So to 90 per cent. of these identical men have been replaced by the Mitchell Stacker and Loader, made by Messrs. Fraser & Chalmers, Ltd., and every machine installed will have the same beneficial effect. It is a simple machine that can be handled by the roughest unskilled labour, that requires very little power, and it will pay for itself in a very short time. It consists of an ordinary band conveyer, mounted in such a way that it can be extended in either direction, turned on a pivot to any position in plan, racked to any angle of inclination, and wheeled along to any position required. The telescopic movement is performed by a rack and pinion, the changing of the inclination by a similar device, while a man can easily revolve the machine by hand about the centre pin, or wheel the whole along the track.

The driving power is furnished by a small steam engine, electric motor, or by an oil engine. The loaders are made for capacities up to 200 tons per hour, and will take any size material.

The machine as shown in Fig. 89 is used as a stacker. The receiving hopper is placed close to the door of the truck to be discharged and the delivery end extended as required. The material to be stacked is then raked from the truck into the hopper, from which it is conveyed to the heap by the band. Several rail-tracks can be placed parallel to one another at regular intervals if a larger storage area has to be filled.

Fig. 90 shows the same machine as a loader, for replacing the material back in the trucks. It is simply turned round and the hopper allowed

to bear against the heap. The material above the level of the hopper is then raked down into it, and all below (about 2 ft.) shovelled into it. As the heap recedes the conveyer extends automatically by its own weight, so that the hopper is always kept tight

The cost of upkeep and depreciation of this machine is less than that required on baskets to do the same amount of work.

This conveyer can also be used with great advantage for handling sacks, etc., and for loading vessels at the

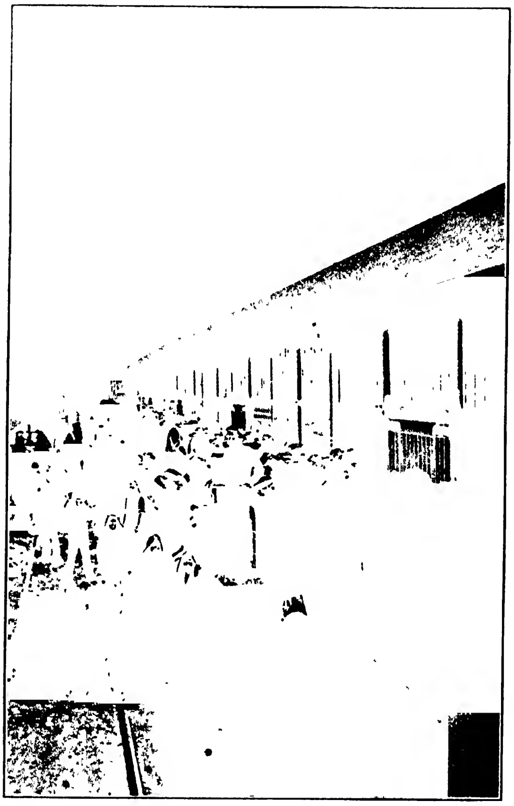


FIG 88—GANG OF MEN EMPLOYED IN HAND-STACKING

against the heap. The only material that has to be shovelled is that actually below the hopper level, and the work on this comparatively small quantity is identical with the filling of baskets in the old method, without, however, all the carrying and lifting.

quayside where no special loading machinery is provided.

The annexed table gives the dimensions and capacities of the different sizes of the Mitchell Stacker and Loader :—

Ref	A	B	C	D	Size of Belt	Size of largest lumps that can be handled	Capacity of Belt in cubic feet per hour	H P required	Net Weight in cwts
	Feet	Feet	Feet	Feet	Ins				
1	30	40	14	18	30	15" cube	1,200	3	60
2	,,	,,	,,	,,	24	12"	2 700	3	55
3	,,	,,		,,	20	8"	1,800	3	50
4	,,	,,	,,	,,	16	4" ,,	1,200	2	45
5	22	32	9	12	30	15" ,,	4,200	2	54
6	,,	,,	,,	,,	24	12" ,,	2,700	2	50
7	,,	,,	,,	,,	20	8" ,,	1,800	2	46
8	,,	,,	,,	,,	16	4" ,,	1,200	2	42
9	19	25	8	10	30	15"	4 200	2	48
10	,,	,,	,,		24	12" ,,	2,700	2	45
11	,,	,,	,,	,,	20	8" ,,	1,800	2	41
12		,,		,,	16	4" ,,	1,200	2	38

A portable band conveyer mounted on two large road wheels is made by Messrs Spencer & Co., Ltd, and is shown in Fig. 91. This can be used for goods in sacks and a great variety of other articles except bulk goods. The conveyer is about 50 ft long and entirely self-contained with its electric motor and driving gear. Any number of units can be so arranged that one delivers on to the next, and the distance thus covered by the goods is practically unlimited. Generally the machines are used for conveying from a warehouse to a vessel or railway truck, and *vice versa*, and also for removing goods from one part of a warehouse to another.

Portable appliances for stacking sacks are also made by Messrs Spencer, in which both a canvas rubber band and special chains are used as the mechanical medium to elevate the sacks. Floor space in warehouses is too

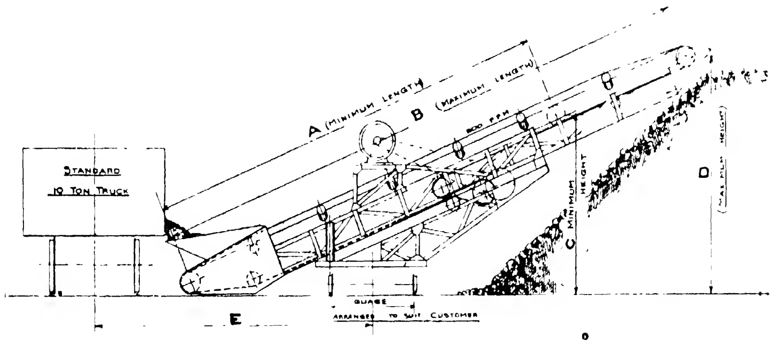


FIG 89 THE MITCHELL STACKER EMPLOYED AS AN UNLOADER

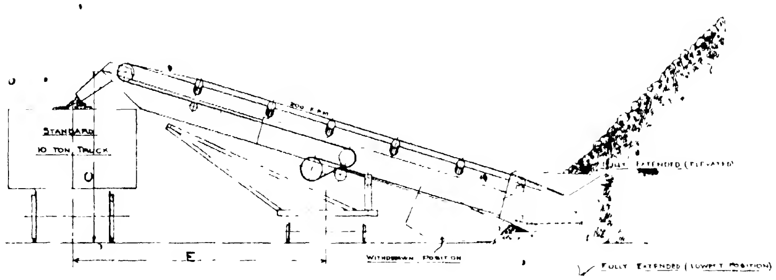


FIG 90 —THE MITCHELL STACKER EMPLOYED AS A LOADER

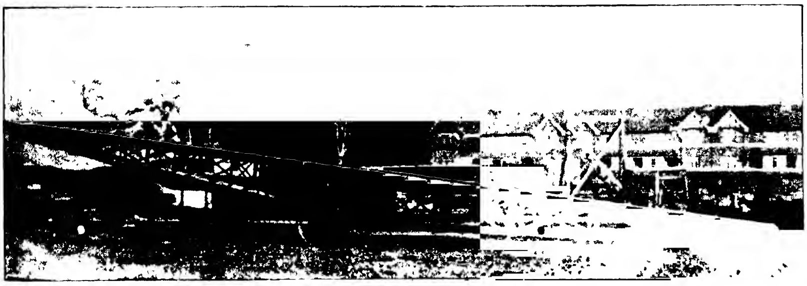


FIG 91.—SPENCER'S PORTABLE BAND CONVEYER

valuable to accommodate only a single covering of sacks, and to store them two deep is all that can be done conveniently by manual labour. The third layer would be costly to place by hand and gang-planks, not to speak of stacking them right up to the ceiling or roof. Machines which will do this work, made by the aforementioned firm, are shown in Fig 92. fitted with an endless canvas-rubber band, and in Figs. 93 and 94 with two endless chains connected by traverses running on wheels at each end. The canvas-rubber band is provided with hard wood slats to increase the friction between the sack and the band, and thus prevent the sacks from sliding back when an incline of over 20° or thereabouts has been reached Both machines have a considerable range of adjustment.

The portable inclined conveyer with the band (Fig. 92) will deliver at any point between 7 ft. 6 in. and 15 ft. 6 in from the ground. The varying incline of the conveyer is adjusted by hand and screw gear which raises or lowers the framing from the axle of the two large diameter travelling wheels, the receiving terminal of the band remaining permanently in the lowest position An automatic feeding device is coupled to and driven from the main conveyer, in the form of a small auxiliary slat conveyer. A special

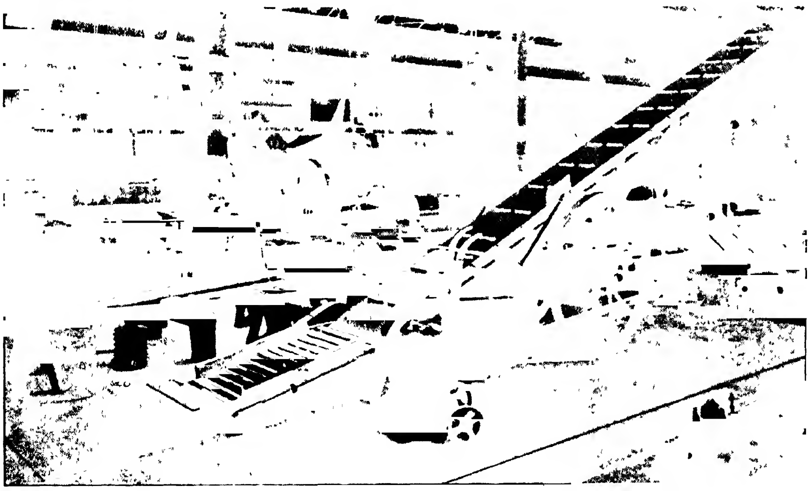


FIG 92.—SPENCER'S ENDLESS BELT SACK STACKING MACHINE

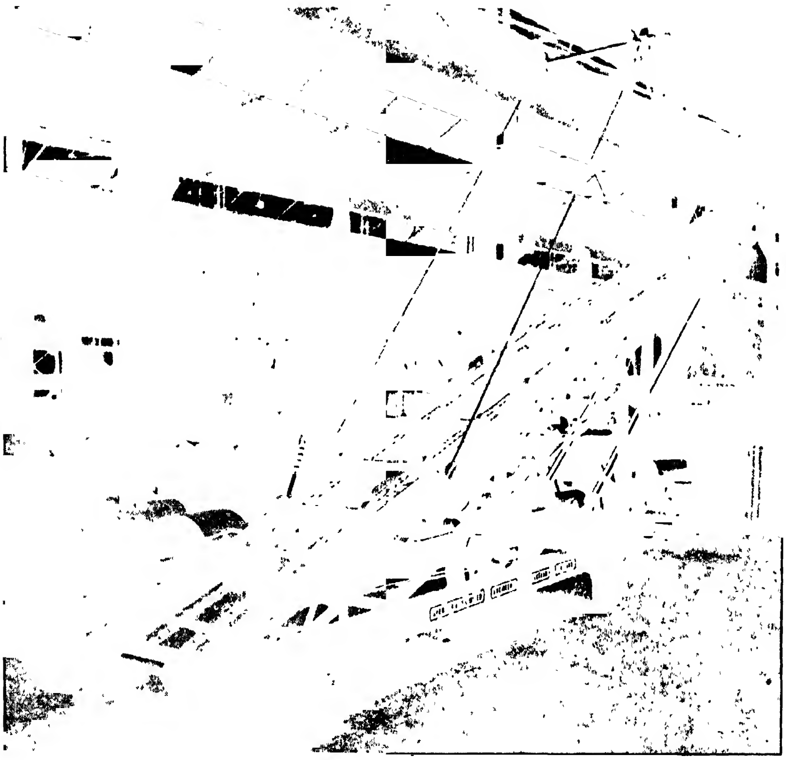


FIG 93 —SPENCER'S ENDLESS CHAIN SACK STACKING MACHINE, IN LOWEST POSITION

sack-truck is shown in the illustration, with a steel plate hinged at its lower end. The loaded truck is run upon the wooden ramp, also shown, and on the hinged plate being released the sack slides off the truck via the feeder on to the conveyer. Several men can feed the band with sacks while one man stands on top of the stack and adjusts them on the pile. As a matter of fact, the conveyer will take the sacks as fast as they can be put on.

The electric motor which drives the conveyer as well as the gearing—which latter reduces the speed from a comparatively fast motor to a judicious band speed of from 100 to 200 ft. per minute—are snugly stowed away between the framing and in steel casings, so that the machines can be left in the hands of the most unskilled labour. All they have to do beyond feeding the conveyer is to move it into fresh positions and adjust the incline as occasion arises.

The chain-driven sack-piling elevator is shown in two positions. Fig. 93 represents the machine in its lowest, while Fig. 94 shows it in its highest, working position, the difference in height being 11 ft. and 22 ft. above the ground. The hand-winch adjustment will, of course, permit of any intermediate position. The machine is mounted in this case on four swivelling wheels for easy turning. The motor, countershaft, and chain drive to the lower terminal are all clearly visible in the illustrations.

Fig. 95 represents a sack stacking elevator of the Hepburn Conveyer Co., Ltd., Wakefield, which needs no further explanation after the preceding description of a similar device. The speed of the sacks is given as 80 ft. per minute, and they can be stacked up to a height of 25 ft.

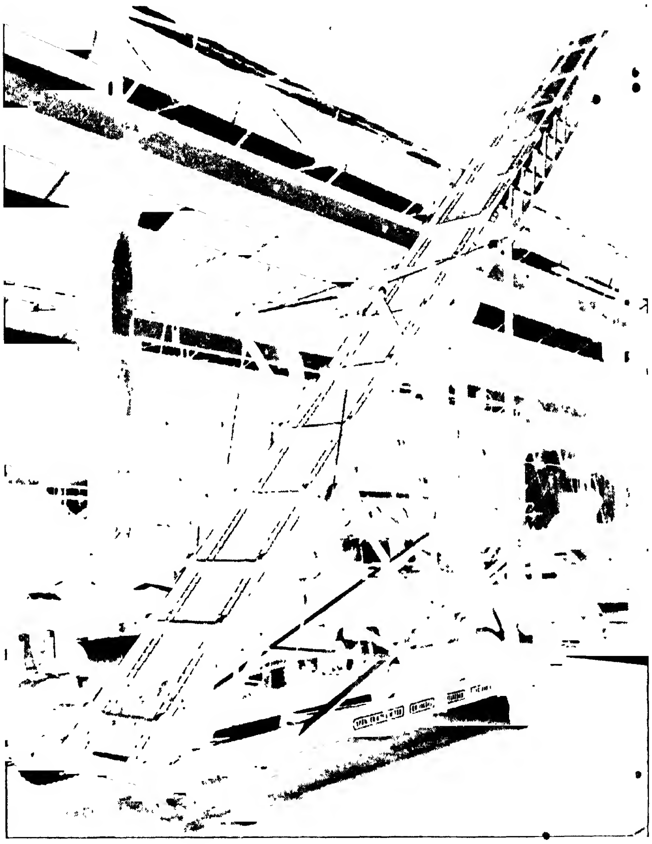


FIG. 94.—SPENCER'S ENDLESS CHAIN SACK STACKING MACHINE, IN HIGHEST POSITION

Where goods in cases or similar articles have to be stacked, Messrs. Spencer recommend their vertical elevator in preference to the inclined machine, and such an appliance is shown in Fig. 96. The overall height of this particular machine is about 23 ft., but it is made for warehouses of any height. The motor which drives the elevator is reversible, so that the same apparatus can be used with equal facility for forming the stack and for removing packages from the stack. Hinged tables or platforms are provided and these can be used in the following manner By means of a hand winch one of the tables is adjusted to the same level as the existing stack, or thereabouts ; the motor is next started, so that the elevator will ascend at the side remote from that on which the platform has been adjusted. Any packages placed on the receptacle on that side of the elevator will now

ascend, negotiate the upper terminal, and descend on the other side until the platform is reached, when the receptacle continues on its downward path, leaving the package, however, on the platform, where a man receives it and transfers it to the stack In order to disperse the stack, the adjustments are slightly modified. The motor is reversed, that is, runs in the opposite direction, and if a package is now removed from the stack and placed upon the platform, one of the now ascending receptacles will lift it from the platform, ascend over the slipping backwards when the ship is high out of the water and the conveyer is working at a steep incline. The machine is driven by an electric motor through suitable gearing at the side of the conveyer. It is mounted on a pair of large diameter road wheels at about the centre of its length, and it is also fitted with a pair of smaller wheels at either extremity The overall length of the conveyer is 53 ft. The apparatus is reversible, so that baggage can be discharged from the ship on to the quay

Similar baggage conveyers are made

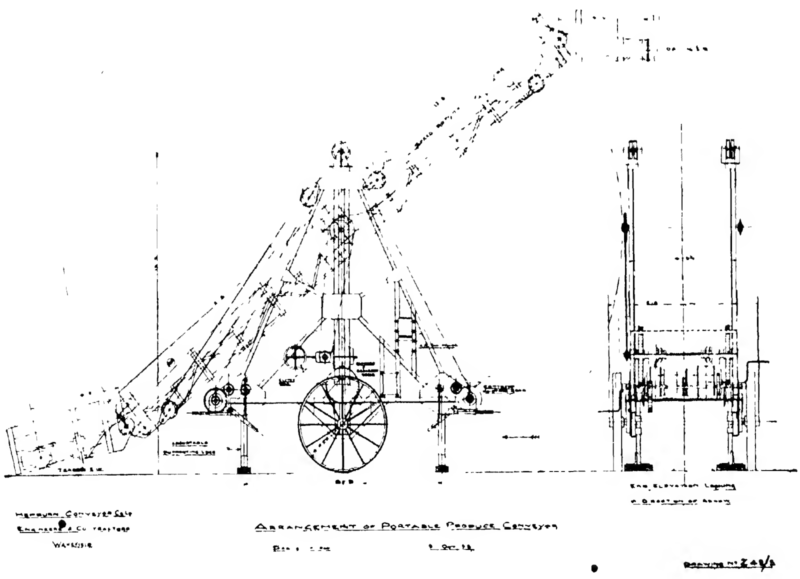


FIG. 95—HEPBURN'S ENDLESS CHAIN SACK STACKING MACHINE

upper terminal of the elevator, and descend on the other side until it is impeded by a similar platform, which will arrest the package while the receptacle proceeds on its endless journey round and round

Baggage conveyers (see Fig. 97) for taking passengers' luggage from the wharf and discharging it on the decks of large Atlantic liners. The baggage is placed on an endless belt 4 ft. 3 in. wide, fitted with wood slats which prevent any possibility of the articles telescopically, to shorten them when not in use, in order to facilitate their movement on the quay They are only 30 ft long in the closed position, and can thus be utilised for all distances between 30 and 50 ft. The makers of these machines are also Messrs. Spencer & Co., Ltd., of Melksham, whose labour-saving devices are so well known.

An armour-plated band conveyer is shown in Fig. 98 in side view, and Fig. 99 in end view It is 25 ft. long,

but can be any length commensurate with easy transportation. Such conveyers are used for handling gritty materials and run at from 50 to 120 ft. per minute. They are also used to convey bricks from the kiln to motor lorries, carts, or railway trucks, and in the side view, and two adjustable stanchions, one at either end, keep the conveyer steady. These latter supports are really not necessary, but as the conveyer is kept in the same position for some considerable time while each kiln is being emptied, it

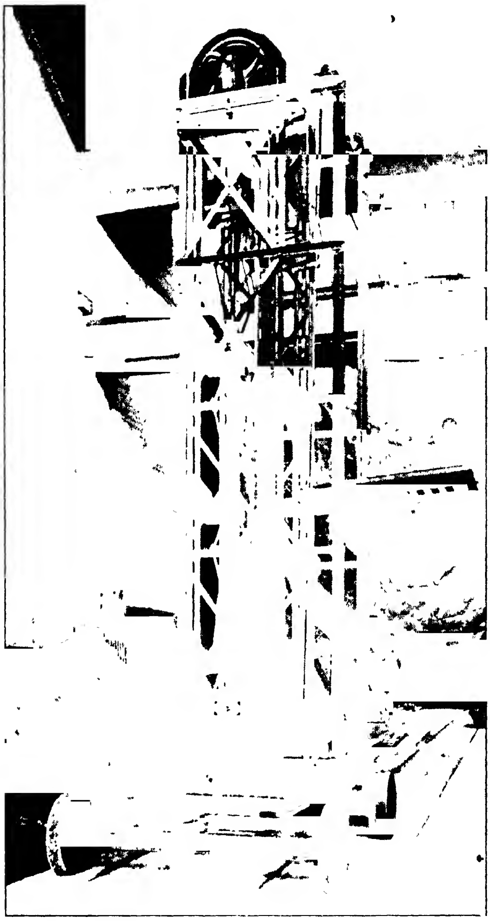


FIG. 96.—SPENCER'S VERTICAL STACKING ELEVATOR FOR PACKAGES OTHER THAN SACKS

Fig. 100 shows one thus employed. Like all the foregoing examples, this conveyer is driven by electric motor and is portable on fair sized road wheels. Its height is adjustable by means of the four hand wheels shown was thought quite worth while to fix them well in position and thus protect them against accidental disarrangement.

The endless belt is of solid-woven bituminised cotton canvas, and the

FIG. 97.—SPENCER'S LUGGAGE CONVEYER

armour plating is introduced to protect the belt from the cutting effect of the bricks The steel strips are heavily japanned and fastened to the belt by two or three pronged fasteners clinched over on the underside.

Before the introduction of these conveyers the average cost of loading into carts by hand was 1s per 1,000 bricks Only one vehicle could be loaded at the time by two men, and this took on an average one hour. We use the term "average" advisedly, because at the front of the kiln it will be recognised as infinitely less costly than when the bricks have to be brought right from the inside or back portion of the kiln With the conveyer in operation the same two men load in one hour three motor lorries, equal to the work of six men formerly. It must also be pointed out that in addition to the actual saving of labour, the vehicles are not standing idly waiting, as they formerly did

The cost of loading 1,000 bricks is now a small fraction over 4d, which sum includes power, men's labour, upkeep and wear and tear, renewals, interest and redemption charges, in fact, everything and on a liberal scale. The threefold increase of turnover

means also that the kilns do not cool down so much, as they are available for new charges much quicker. One man can wheel the conveyer from place to place on a well-paved yard, but when the yard is soft two men are required, and the same two men can do all that is necessary to adjust the conveyer in position, connect the flexible metallic hose encasing the wire, start the current, and then load the conveyer.

of the Hepburn Conveyer Co , Ltd., of Wakefield.

Portable bucket elevators are very suitable for reclaiming the deposits from settling tanks or pools which are frequently found in connection with mining plant. Whether such tanks are enclosed by concrete walls or whether simply holes in the ground, it matters not, but as the portable elevators are mounted on rail tracks, it is more economical when laying out

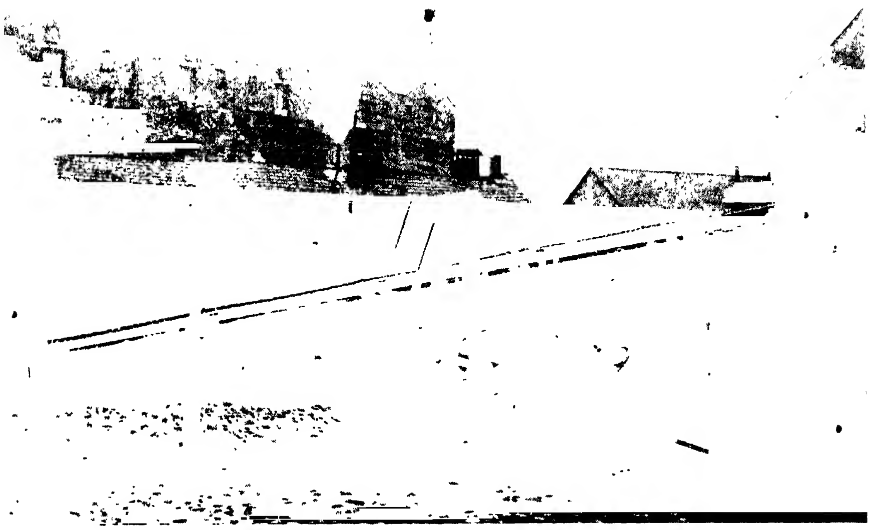


FIG 98 —HEPBURN'S ARMOUR-PLATED BAND CONVEYER, SIDE VIEW

A similar conveyer is shown in Fig. 101. It is suitably mounted on a lattice frame hinged to fixings on an ordinary Bolster wagon, and arranged with a sliding base and composite petrol motor driven gearing. It is used in connection with railways, gasworks, quarries, and in any place where stacks of granular material are to be loaded or unloaded.

Fig. 102 is a similar conveyer, but instead of running on a railway track it is fitted on a motor lorry base and broad traction wheels for use on soft ground. These conveyers are the work

a new settling pool to give it an elongated rectangular form, not less than 50 yards long, so that the elevator can reach right across, and best of all to have one such pool on each side of the rail track.

Usually such elevators are of the non-enclosed chain type, and as they generally work in an inclined position, the chain of buckets must be frequently supported by guide rollers. The whole of the elevator is supported at its centre on trunnions resting on the portable steel frame. The power consumed in driving such an appliance

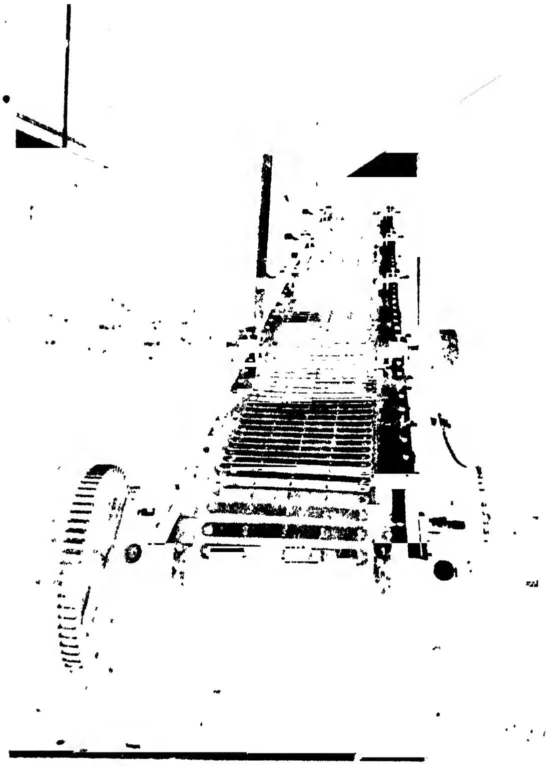


FIG. 99.—HEPBURN'S ARMOUR-PLATED BAND CONVEYER, END VIEW

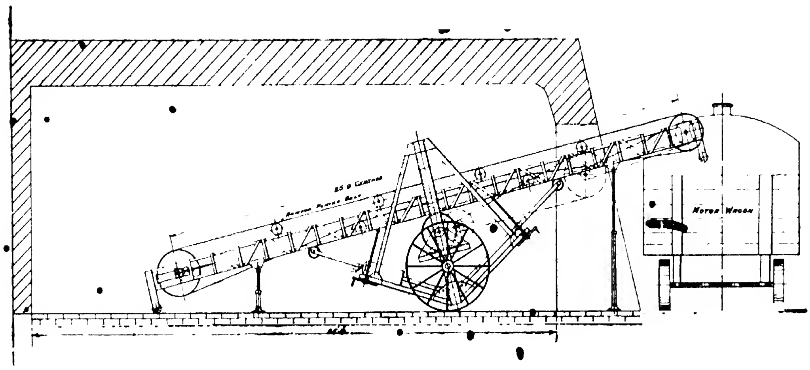


FIG. 100.—HEPBURN'S CONVEYER EMPLOYED IN EMPTYING BRICK-KILN

is 6 h.p. for a capacity of 20 cubic yards per hour. Figs. 103, 104, and 105 show different ways of applying the apparatus.

By the kind permission of *The Engineer*, we give the following description* of one of the latest of the many labour-saving devices used in the United States. It is a portable and self-propelling elevator for loading loose materials—such as sand, gravel, broken stone, coal, etc.—into carts, railway wagons and wheelbarrows. It is made in different forms, one of which is represented in Fig. 106. Here a steel frame carries an endless chain of buckets which pick the material off the ground and discharge it at the top into a bin and spout. The frame is mounted upon a pair of "caterpillars," each of which has its own motor, the machine being turned and steered by varying the speeds independently. It can feed itself against the pile of stone or gravel, and can move about the yard at a speed of 75 ft. per minute. Its weight is a little under 3 tons. It measures about 15 ft. high overall, 7½ ft. wide, and has a bearing of 4½ ft. between centres of "caterpillar" sprockets. The 25 buckets have a capacity of one yard, and discharge at the rate of thirty buckets per minute, so that fully one cubic yard per minute is delivered. The bucket

* From *The Engineer*, of June 27th, 1913

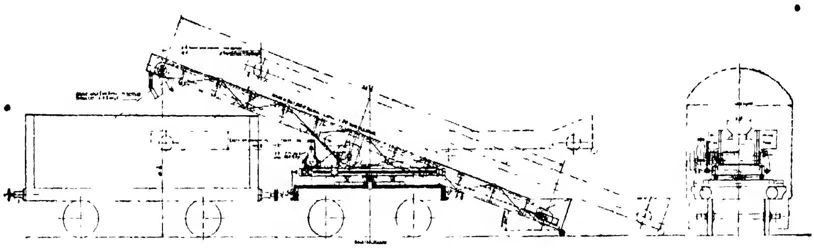


FIG. 101.—HEPBURN'S PORTABLE LOADING CONVEYER, MOUNTED ON RAIL TRACK

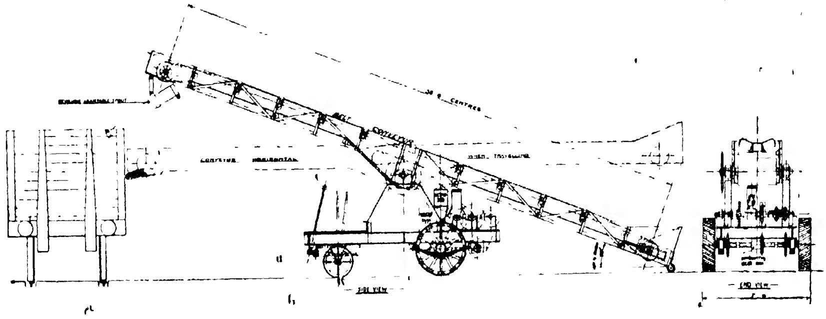
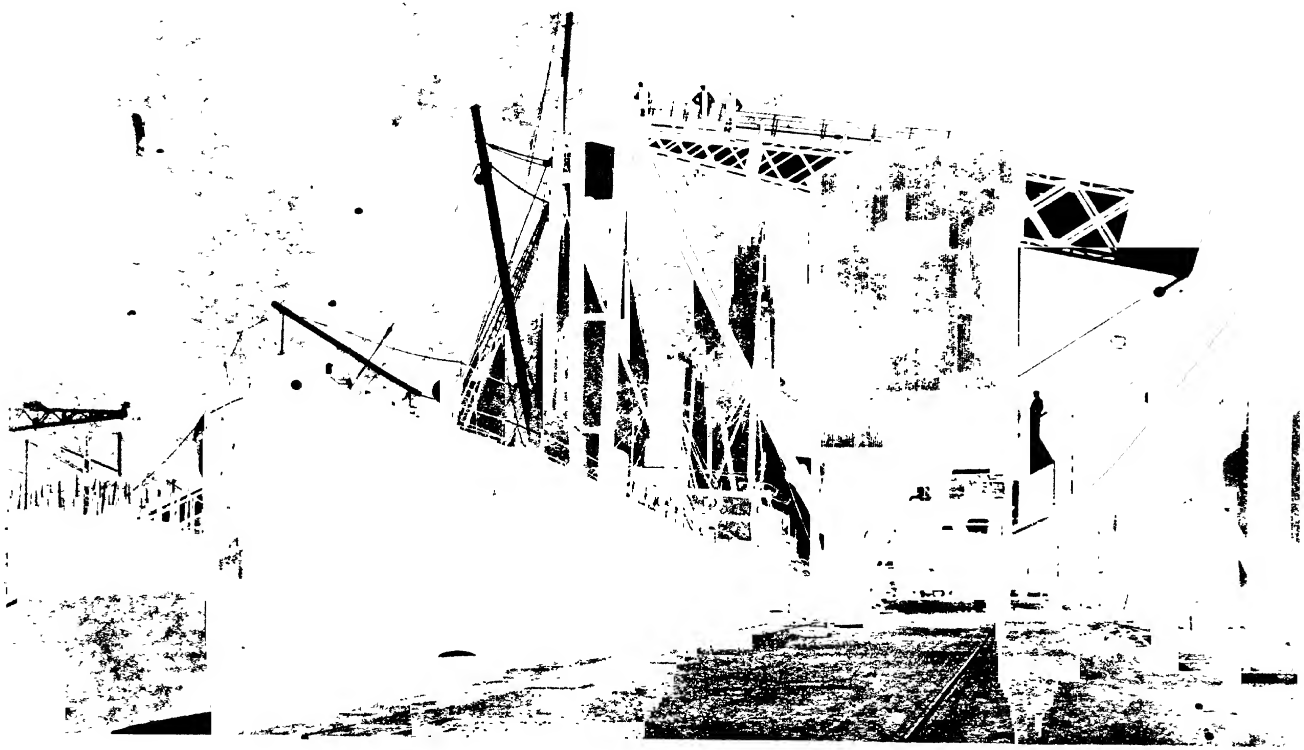


FIG. 102.—HEPBURN'S PORTABLE LOADING CONVEYER ON MOTOR LORRY



One of two Ship-Discharging Grain Elevators at Meadowside Granaries, Clyde Navigation Trust, Glasgow; capacity 250 tons per hour each. Erected by SPENCER & CO., LTD., Melksham.

chain is driven by a steel link belt which passes over a motor-driven drum on the frame and over a sprocket on the bucket shaft at the head of the ladder. Motors of 5 h.p. are used.

For loading into wheelbarrows and tubs or into the small railway trucks used at quarries and stone crushing plants, this high machine is replaced by one having a ladder frame of a much flatter angle, or even horizontal. Some of these machines have to revolve by turning the entire machine, as in the case illustrated. In others, the ladder frame is mounted on a turn-table base on the underframe, so as to revolve independently of the movement of the "caterpillars" These weigh from 3 to 10 tons, according to size, all being of the same general type, except that the buckets are driven by gearing from a motor on the ladder. A development on a larger scale is a machine for unloading barges and railway wagons In this case a gantry spans the rails or canal slip, and on it traverses a frame carrying a curved ladder or bucket boom which can be raised, lowered and swung as desired The vertical end of the ladder extends into the hold of the boat or the body of the truck, and from the upper horizontal end the buckets discharge material upon a conveyer belt. These machines are being introduced by the George W. Jackson Manufacturing Company, of Chicago.

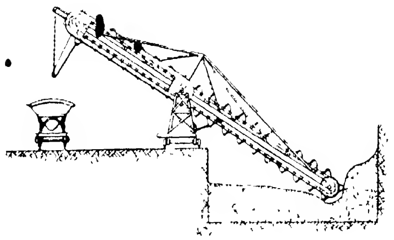


FIG. 103

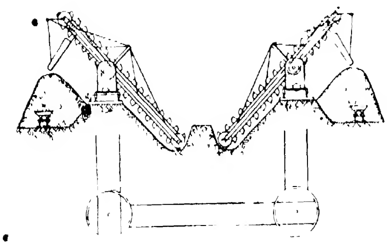


FIG. 105

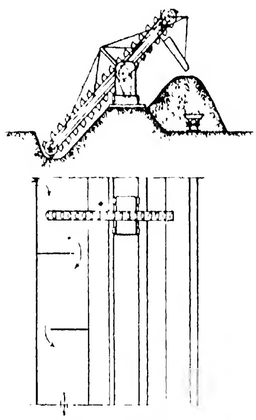


FIG. 104. PORTABLE CONVEYERS IN CONNECTION WITH SETTLING TANKS

The Jeffrey Loader is a most versatile machine on similar lines, and is executed in a variety of designs differing but little in outer appearance, but embodying attributes which make them applicable to all kinds of loading from off the ground to anywhere within their reach When the first machines were designed they were intended for handling anthracite coal, but they are now made to handle small bituminous coal, sand, gravel, fine cement, fertiliser, and such-like materials. They can be moved according to the condition of the ground by one or two men, and if it is desirable to load or unload some distance off, the loader can be hitched to the wagon and hauled to the scene of action These loaders can be made with and without feeder attachments, the use of which is of considerable advantage, as this device pulls the material to the elevator buckets and dispenses with human labour for pushing the material down the pile into

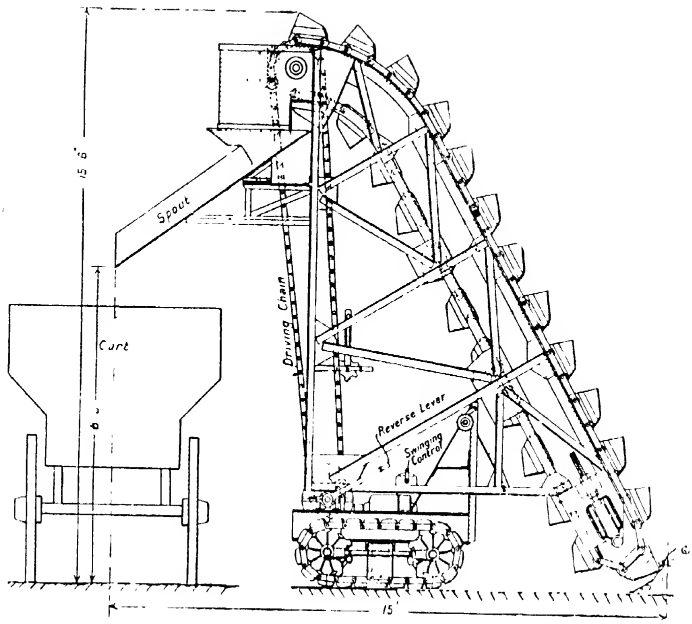


FIG. 106.—BULK LOADER OF THE JACKSON MANUFACTURING COMPANY

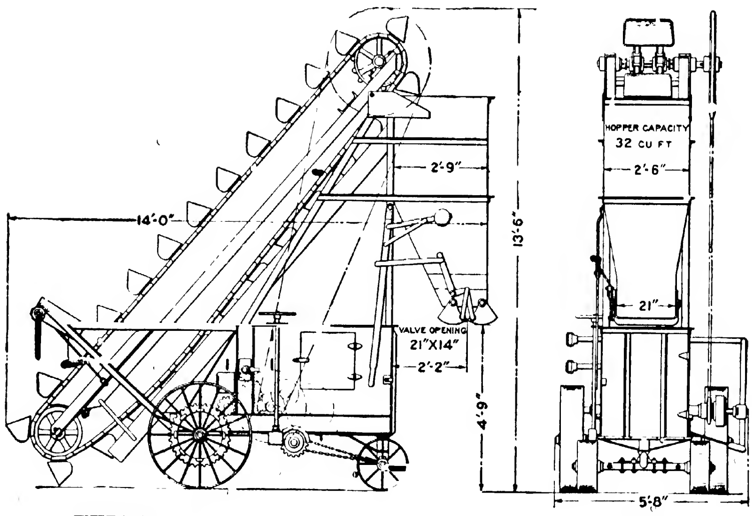


FIG. 107.—BULK LOADER OF THE JEFFREY MANUFACTURING COMPANY

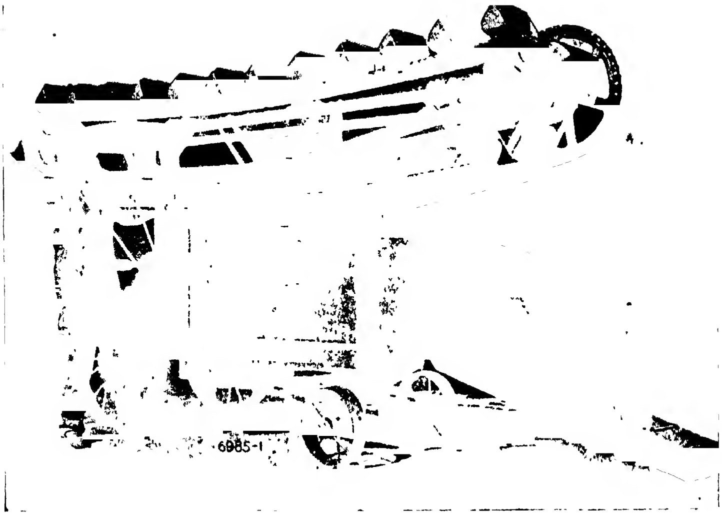


FIG. 108.—JEFFREY LOADER IN HOUSED CONDITION

the machine. The feeder conveyer can be raised and lowered by cable and hand-winch; the cable runs through telescopic pipes which protect it from becoming entangled with the running machinery; a shaker screen can be provided by means of which the coal, etc., can be sifted before

FIG. 109.—JEFFREY LOADER HANDLING SAND

FIG 110 —JEFFREY LOADER WITH SCREEN, HANDLING SAND

loading. The machines are made self-propelling, and require only one man to operate except when the elevator is raised or lowered, when two men are temporarily necessary These machines are built for capacities of from 40 to 60 tons per hour An attachment may also be had for bagging the material, particularly coal, by raising a hinged plate at the end of the shaking screen the coal can be made to drop into a bag hopper after having been screened, the sacks are attached to the discharge spout, and are filled by opening a valve. Or a shoot can be provided which extends to one side of the machine, so that the sacks can rest on the ground while being filled

With the previous description of

FIG 111 —JEFFREY LOADER HANDLING CRUSHED STONE

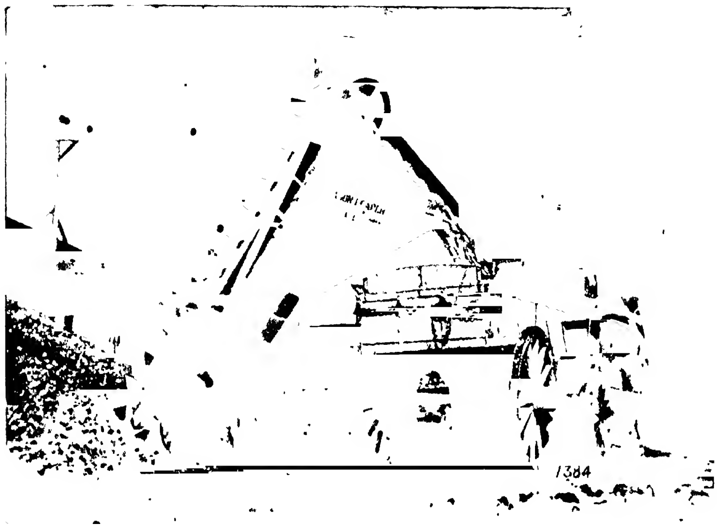


FIG. 112.—JEFFREY LOADER HANDLING ANTHRACITE COAL AND SCREENING IT AT THE SAME TIME

similar machines the accompanying illustrations should require no further explanation. Fig. 107 represents the general arrangement of the type of the machines, Fig 108 the machine housed for transport. The dust hopper is removed and is seen lying on the ground Fig 109 shows a motor-driven loader handling sand at the rate of one cubic yard per minute (note the serrated edge of the buckets). In Fig 110 we have a loader equipped with screen and dust hopper for handling sand Fig 111 represents a loader driven by a gasoline engine, handling crushed stone from a storage

FIG 113—OLD METHOD OF HANDLING FERTILISER BY HAND SHOVELLING

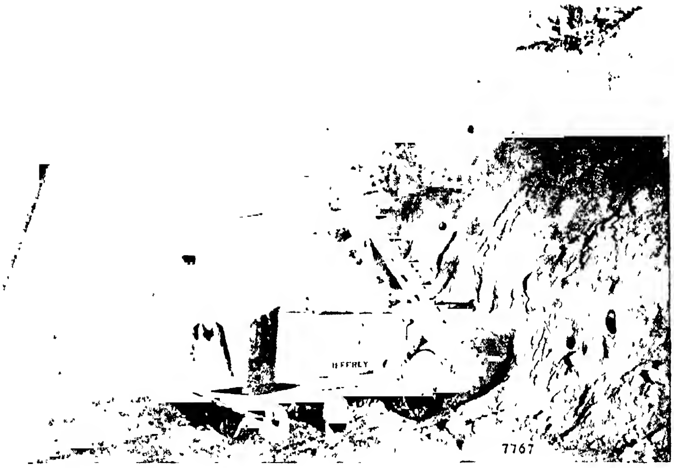


FIG. 114. JEFFREY LOADER HANDLING FERTILISER

pile to a railway truck Fig. 112 is a loader handling anthracite coal and screening it at the same time

For handling fertilisers these loaders are most successfully used, taking, for instance, the raw material to the mills, whereby practically all shovellers are eliminated, and the number of wheel-barrow and car men is reduced, as they do not have to wait for their load. When operating on a pile of hard complete fertiliser, a loader will dig itself in automatically until the material thus undercut breaks loose from above and sometimes even buries the lower end of the machine, but such a caving in will in no way interfere with the handling, and in case of a jam the clutches will slip and prevent breakage. When loading soft goods no pickers are necessary on the pile as the material will likewise slide down to the loading point All shovelling, with the exception of that of one man, can be dispensed with, and he is only used to clear away under the wheels of the machine as she moves into the pile. Fig. 113 shows the old-fashioned method of handling fertiliser by hand-shovelling, and at the same establishment the introduction of the Jeffrey Loader has dispensed with half the men, and the scene appears now as shown in Fig 114, in which the loader is seen just starting to work on a pile of acid phosphate which has stood for two months The substantial construction of the machine will permit of its being driven into the pile under its own power at the rate of 4 ft per minute. As much as 4½d. per ton has been saved in handling fertiliser in this way The British agents for the Jeffrey Manufacturing Company are Messrs. Hugh Wood & Co, Ltd. London, who have an American expert on their staff, and can therefore answer all questions concerning these machines immediately without having to refer to their principals across the water.

A portable loading and unloading device not on wheels, like those previously described, but suitable for handling and placing in position by a crane, is one of the most important, it is applicable to the handling of practically all goods in and out of ships, and is known as Donald's patent ship elevator-conveyer, manufactured by Rownson Drew & Clydesdale, Limited, London. We say "practically all goods" advisedly, but we

might have almost said "all goods"; for although this system is more usually employed for larger individual loads, by changing the carriers it can handle bulk goods nearly as well as a bucket elevator. The goods for which this system is more generally employed are objects in barrels, sacks and cases, crates of bananas, rabbits, poultry, etc., as well as cheese, carcases of mutton, and even quarters of beef. Like all elevators and conveyers, this loader is continuously working, and individual loads are generally placed into its receptacles or "slings," as they are called, by a gang of men. The speed at which the elevator-conveyer works is 60 ft per minute, and the pitch of the receptacles or "slings" varies between 2 ft. 6 in. and 3 ft. 4 in., so that it requires a gang of six men to keep the elevator fully loaded. The use of this appliance means larger capacity with the same number of men, small wear and tear, less noise and less damage and breakage to the goods handled. The machine can readily be adapted to any rise or fall of the ship due to alteration in the water level or the cargo working, and the same machine can be used equally well for loading or for unloading.

For specific purposes the elevator-conveyer is built first, portable, secondly, semi-portable, say at the quay, and thirdly, attached to a warehouse on the quay. The first, portable, is the most usual form, where the machine is bodily lifted by a crane on to the deck of the ship to be cleared. The second type is carried from a gantry with an extended jib, so that the vessel can be plumbed in a few minutes, while in the third type the machine is usually cantilevered from the top of the warehouse and is chiefly used for loading and unloading lighters and other small craft. As we are dealing with portable devices, we must only investigate the first of these three types, but the principle is the same in all three. One of the self-sustained portable Donald elevator-conveyers is shown in Fig. 115 in the act of being lifted aboard a White Star liner for unloading purposes. Fig. 116 gives a nearer view of the machine on a carriage being wheeled alongside the ship preparatory to being lifted aboard. This particular machine is one of five supplied to the London and North Western Railway Company at Garston Docks for unloading bananas from Elder's & Fyffe's steamers. The view shows how the machine can be reduced to its minimum size in its housed position, the carriers are all looped close together and the chains can be seen festooned along the upper part of the framing, the two terminals but slightly overhanging, one at each end of the machine. The apparatus in its housed condition is placed aboard in such a way that one of the terminals plumbs the hold, and the other extends over the side of the vessel and reaches either on to the quay or over a barge alongside, or, in fact, reaches over to the spot where the cargo is to be dumped. The receiving terminal is now slowly lowered into the hold

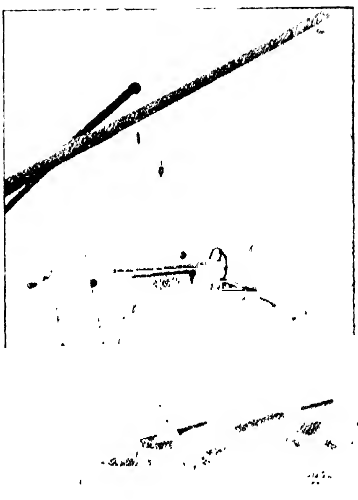


FIG 115.—LIFTING DONALD'S ELEVATOR-CONVEYER ABOARD A WHITE STAR LINER

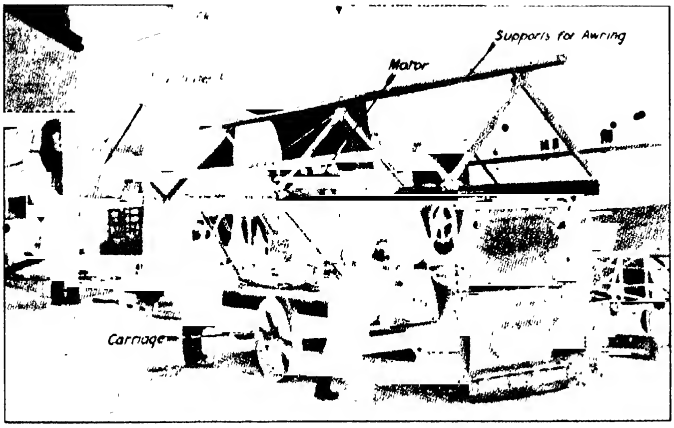


FIG 116 —DONALD'S ELEVATOR-CONVEYER ON TROLLEY

and a balance weight which has been previously lowered is attached to that end. The delivery terminal is now lowered in like manner on to the spot where goods are to be received. The normal machine is of such dimensions as to reach to the bottom of the hold of an average vessel and likewise to reach down to the barge or dock level alongside. The portions of the strand of the conveyer not in use at any one time are accommodated in a supplementary bight formed by an additional, what might be named intermediate terminal. This terminal consists mainly of a pair of sprocket-wheels on a spindle which can slide back and forth on a prescribed horizontal path. By allowing the movable terminal to travel in one direction, the conveyer can be extended to its uttermost limit, by increasing the vertical bights and so reducing the lengths of the chain in the supplementary bight If the movable terminal is taken in the opposite direction the vertical bights are shortened. The diagram, Fig. 117, will elucidate

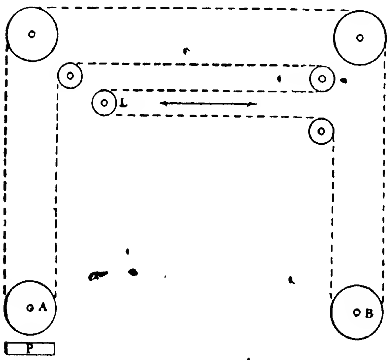


FIG 117.—DIAGRAM SHEWING METHOD OF SHORTENING AND LENGTHENING ELEVATOR-CONVEYER

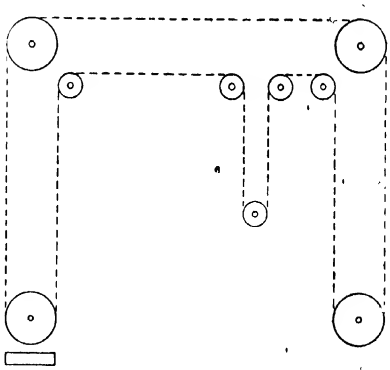


FIG 117A —ALTERNATIVE SCHEME TO FIG 117

FIG 118 RECEIVING TERMINAL OF DONALD MACHINE

this A and B are the two main terminals, A being lowered into the hold and there held taut by the hanging weight P, while L is the intermediate terminal which by its lateral motion can take up slack or pay out chain as may be required Fig. 117a is an alternative scheme The end terminals consist of a pair of sprocket-wheels and the distance apart of these wheels will be determined by the size of the objects to be loaded; thus, for carcases of mutton the sprockets and the chains are 5 ft 6 in. apart, while for quarters of beef they are 7 ft. apart, the carriers themselves are formed of canvas slings or loops and are 18 in. narrower than these dimensions, in order to leave a clearance of 9 in. at each side between the sling and the centre of the chain, so that the sling for mutton would be 4 ft. wide and for the quarters of beef 5 ft. 6 in., and for all other cargo in proportion. We might say that the 4-foot sling will handle most things, such as cheese, crates of bananas or rabbits, carcases of mutton, and most goods in barrels and sacks. The makers do not recommend these conveyers for quarters of beef (though they have executed machines for dealing with such satisfactorily), as they are too unwieldy in size, and tax the capacity of an ordinary ship's derrick.

The chains used are of a very strong pattern, $2\frac{1}{2}$ in. pitch, and special links are provided at regular intervals for supporting the cargo slings These links are cast together with a short tube-like attachment transversely to, but centrally with, the chain into which the end of a length of $\frac{3}{4}$ in. steel tubing fits, where it is secured by rivets so that the chains, with these steel tube lengths traversing and connecting them at regular pitch, have the appearance of a huge rope ladder The slings themselves are attached at each end by stout jute loops to a length of $1\frac{1}{4}$ in steel piping which fits over and is held in position by the $\frac{3}{4}$ in. pipes previously mentioned, the whole being very substantial and exceedingly simple Fig 118 shows one — the receiving terminal of such a conveyer in the hold of the White Star liner *Runic* at Tilbury Dock unloading a cargo of mutton. The steel tube traverses with the attachment of the loops can be seen clearly.

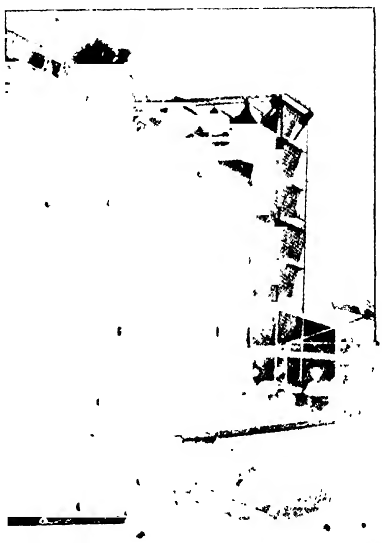


FIG 119 — DELIVERY TERMINAL OF DONALD MACHINE

Fig. 119 shows the delivery terminal of a machine unloading the s.s. *Ayrshire*, of the Shire Line, while Fig. 120 shows the automatic unloading of crates of frozen rabbits ex s.s. *Persick* at the Canada Dock, Liverpool, and Fig. 121 shows an interesting installation unloading bananas from the s.s. *Zent*, discharging automatically on to a band conveyer. This particular equipment comprises four elevator-conveyers and four band-conveyers, all electrically driven, and the rate of discharge exceeds 6,000 bunches of bananas per hour. The illustration shows one bunch just being discharged, whilst the two previous ones are already travelling away on the band-conveyer.

Many of these installations work in connection with portable gravity roller runways, but these are only applicable for cases and crates presenting a flat surface on which they can travel, such as tea-chests, cased fruit, etc., etc.

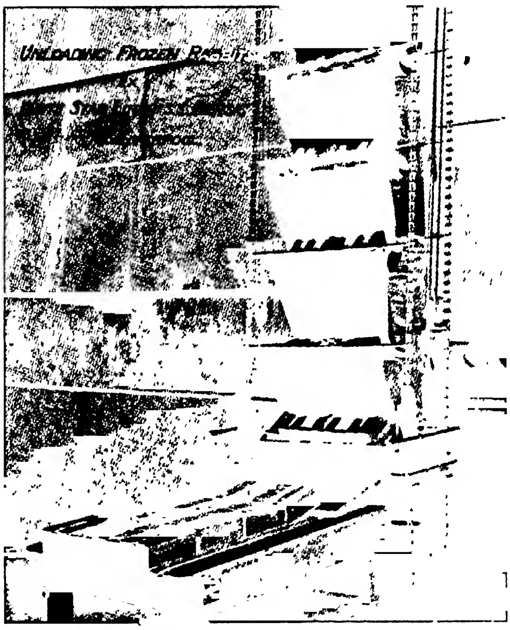


FIG. 120.—UNLOADING CRATES OF FROZEN RABBITS

Roller Runways are generally used more or less as fixtures, but their extreme lightness and consequent portability in short lengths, and the ease with which they can be joined up to form long lengths, makes them very attractive for the handling of individual loads, and, requiring no driving power beyond the gravity of the descending load, enhances their value. Roller runways consist of a series of small diameter rollers $2\frac{1}{2}$ in. to 3 in. and of a length about equal to the width of the object to be conveyed. They run on spindles which take their support and bearings in two longitudinal supports forming units 6 to 8 ft. long, which can easily be joined up. The pitch of the rollers depends upon the dimensions of the cases, as they must rest at all times on not fewer than two rollers; the pitch must not, therefore, be more than half the length of one of the cases to be handled. Thus, if the cases were 6 ft. long, the

rollers must not be more than 3 ft apart, whereas for a case 2 ft. long the rollers must not be more than 1 ft. apart from centre to centre

Such rollers rarely run in ordinary bearings as, if they did, the resistance would be so great that the load would not run down the incline unless it was so steep that the conveying distance could only be very short except the goods had to be conveyed from a great height. The fundamental principle is to support the rollers in such a way as to reduce the resistance to their revolution to a minimum Now, of all the mechanical devices at present at our command, there are none which answer this purpose better than the ball-bearing, the roller-bearing being a good second. The former will permit a well-made box to descend an incline automatically of 3 in 100; for tea chests 4 to $4\frac{1}{2}$ in 100, and for empty cases 6 to 7 in 100; while with roller-bearings the minimum incline is, for good boxes, $3\frac{1}{2}$ in 100, for tea chests 5, and for empties $7\frac{1}{2}$ in 100 We see thus that the ball-bearings have a little advantage over the roller-bearings, but against that will have to be taken into consideration that the roller-bearings last longer and are not so easily damaged by the rough usage they almost invariably receive

Messrs The Hepburn Conveyer Co, Ltd, of Wakefield, are the makers of a portable Gravity Roller Conveyer, which is illustrated in Fig 122. This type of conveyer, which consists of a series of rollers running in ball-bearings, is mounted on a lattice girder underframe. It is used, of course, for lowering only, as the operation is by gravity and automatic, requiring no motive power Such goods as boxes, packed merchandise, etc. (so long as there is a flat base which can slide down a very gradual incline) can be handled by it. As an example, we may mention that for instance cases weighing 40 lbs can be conveyed a distance of 100 ft if a descent of 5 ft. is available, which would be about the

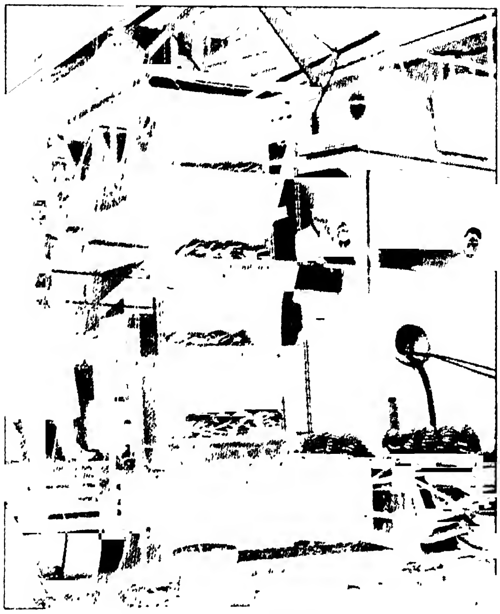


FIG 121 —UNLOADING BANANAS

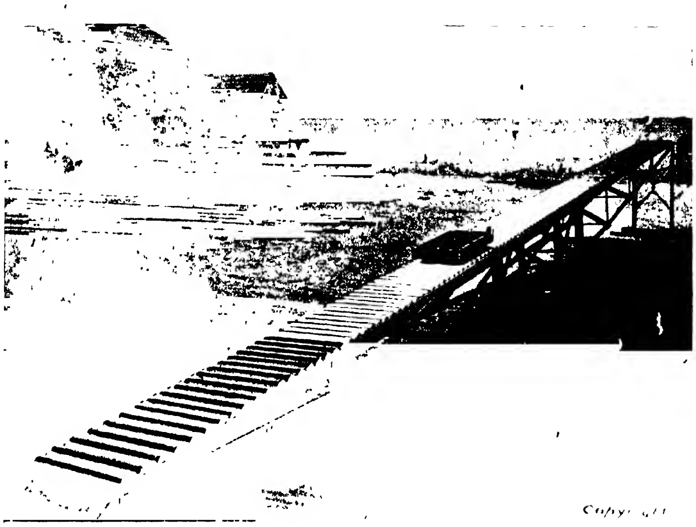


FIG. 122.—ROLLER-RUNWAY MOUNTED ON WHEELS

height of the floor of a railway truck above the ground, but as a fall of 3 to 5 per cent. will be sufficient for the goods to travel by gravity if in suitable cases, it will be seen that, all circumstances being favourable, a distance of nearly 200 ft. could be negotiated if necessary

The machine here illustrated is 56 ft long and is for dealing with wooden boxes in both directions, and the lattice underframe is, therefore, so arranged on a central trunnion that its operation can be easily reversed by tilting the machine whichever way it is wanted. The rollers, as already stated, are provided with ball-bearings and are made of solid cold drawn steel tubes with the ball-bearings at the ends attached to the framework by means of suitable spindles or pins, according to the size of roller employed. This, together with the pitch of the rollers, largely depends upon the class of material to be handled.

Very similar to the gravity roller runs are the

Live Roller Conveyer, the difference being that whereas in the former the object placed on the rollers will run down an incline by gravity, in the latter case the rollers are power-driven, and depend therefore no longer on gravity, but can convey the object placed on them on a level or at an incline up or down.

In rolling mills, where the steel for our high explosive shells is now rolled, as well as plates, rails and bars of all sections, the unfinished rails, bars or sheets have to pass the rolls repeatedly as they assume their final form For this work "live rollers," a form of conveyer are used Ingots, bundles of wire, crop ends, etc, are conveyed by these revolving rollers from place to place without hand-labour. Such live rollers are simply a series of rollers arranged as shown in Fig. 123. Any object sufficiently long to reach across three rollers will, if laid upon this conveyer, travel forward by virtue of the revolving rollers, with at least two of which it will be in contact until it has reached the end of its journey. From the illustration we may easily understand the system. The upper view is the elevation with the rolling mill indicated at the left. From the plan we see better how the rollers are driven by a pair of bevel wheels each. The first three rollers

are close together, all the others being pitched 4 ft. 6 in. apart. The rollers are 40 in. long and 20 in. diameter. In this particular case the whole plant is arranged to be portable on four lines of rails, so that it may be placed opposite any roller mill. M_1 and M_2 are two electric motors, the former for propelling the machine and the latter for driving the rollers.

The chapter on Portable Devices would not be complete without some mention of Floating Devices, of which the following are the latest examples.

FLOATING GRAIN UNLOADERS.

What has been said in connection with pneumatic plant on shore also applies to floating grain unloaders. The system and general arrangement are so similar that an illustration, Fig. 124, will suffice.

There can be no doubt that in spite of the great initial cost of such a plant and the comparatively great power consumption of even up-to-date plants, these pneumatic unloaders are the most important of such floating devices, though the floating bucket elevator is a close second.

It will perhaps be best to compare the respective merits and adaptability of both types before going into a more detailed description. All floating grain unloaders must, of course, be mounted in and upon a pontoon. The pneumatic system, which consumes about four times as much power as the bucket elevator, necessarily requires a bigger engine and boiler, therefore a much larger pontoon, and entails a correspondingly higher expense. The cost of the rest of the machinery is also more for the pneumatic system. An equipment for an hourly capacity of 150 tons requires 50 h.p. for the bucket elevator and 250 h.p. for the pneumatic plant.

The insertion of a rigid structure like that of a bucket elevator into the hatches takes generally more time than the iron or compo-flexible suction pipe of the pneumatic. The way into the hold may be awkward and the ties and bracings lower down may likewise obstruct the way of the elevator leg, and worst of all a great amount of trimming is necessary to get the last of the grain to the elevator, while the pneumatic requires practically no trimming.

In rough weather the bucket elevator cannot be used, while the suction pipe of a pneumatic plant can be led into the hold without admitting the rain. The trimming work being injurious to health and unpleasant on

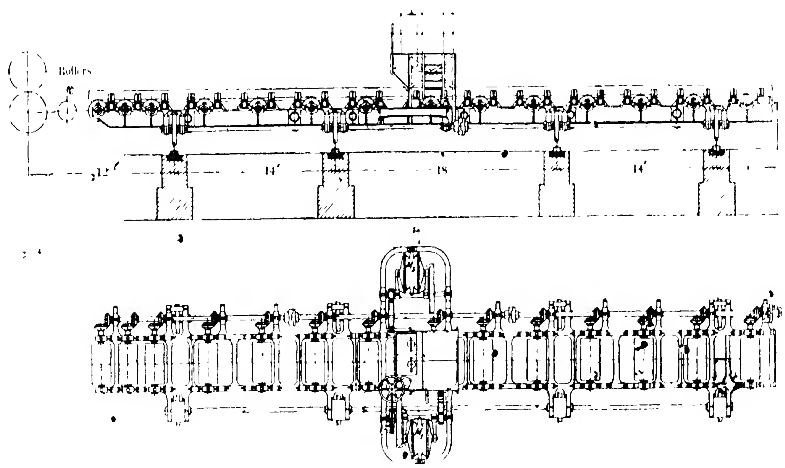


FIG. 123.—INSTALLATION OF PORTABLE LIVE ROLLERS IN CONNECTION WITH ROLLING MILLS

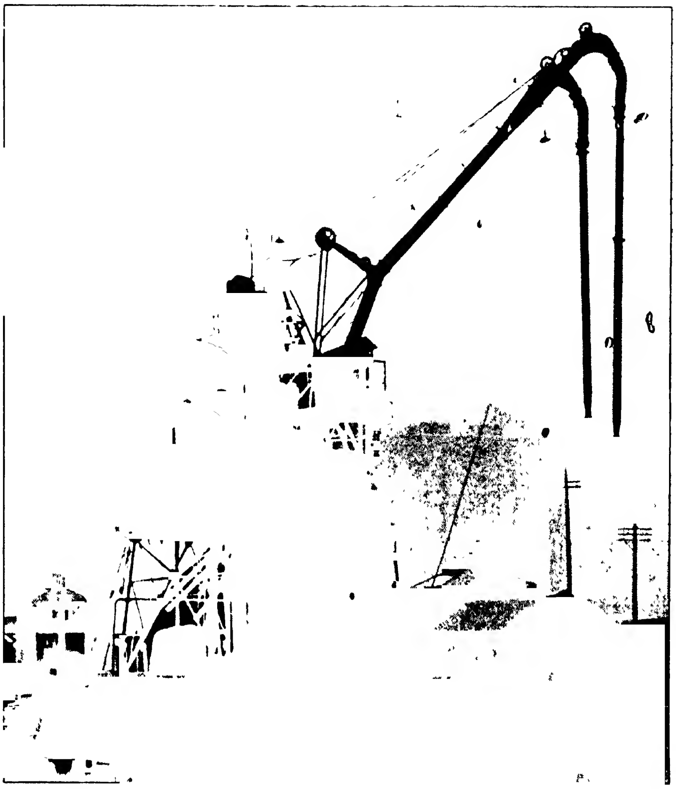


FIG 124 —ONE OF THE FLOATING PNEUMATIC GRAIN ELEVATORS BUILT BY HENRY SIMON, LTD., FOR USE IN THE PORT OF LONDON

account of the dust, requires occasional breaks, with a consequent deficiency in output.

It must also be mentioned that some maltsters object to the use of the pneumatic plant for handling barley in the belief that it is injurious to the grain.

We thus see that although with the pneumatic system the expensive trimming is not necessary, the cost of handling per ton from all causes, interest on capital, fuel, labour, etc., is higher for the pneumatic, but the balance may be on the other side when unloading large ocean-going steamers, in the saving of demurrage.

When one has to choose between the two types all these factors have to be taken into consideration before such an important decision can be made. Generally speaking the pneumatic is more suitable where large cargoes from ocean-going steamers have to be dealt with in ports which constantly and regularly receive such cargoes, that is, all the year round. In all other cases the bucket elevator would be more economical. With reference to the trimming, it is only fair to mention that under some circumstances a large gang of men have to be kept constantly employed for other purposes, and their time when used for trimming may on that account not be so costly as if they were employed purposely for it.

Barges and pontoons fitted with

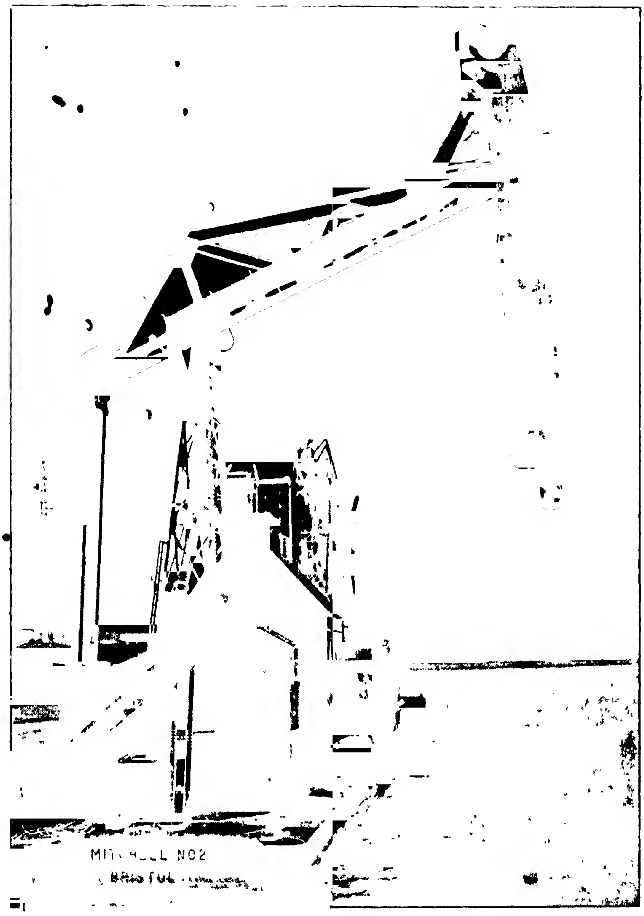


FIG 125 — ONE OF MITCHELL'S FLOATING CANTILEVER GRAIN ELEVATORS AT AVONMOUTH DOCK — IN WORKING POSITION — BUILT BY MESSRS SPENCER & CO, LTD, MELKSHAM

bucket elevators in such a way that the elevator proper, supported from a jib boom, can be dropped into the hold of a grain ship, have been designed and erected in a great variety of ways, but they did not reach their present perfection until Mr. A. H. Mitchell, bulk grain engineer to the Port of London Authority, set himself the task to lavish his inventor's skill upon the problem. The older types have been humorously likened by "The Electrical Times" to a camel with an exceedingly big hump and of such proportions that the animal could neither raise its head sufficiently to bring its chin over the edge of the feeding trough, nor move its mouth freely about the bottom of the trough when the first difficulty had been surmounted, and that owing to its topheaviness the poor beast had to spread its stout legs wide in order that its centre of gravity should not overtop the mark; while Mr. Mitchell's elevator is likened to the far-reaching

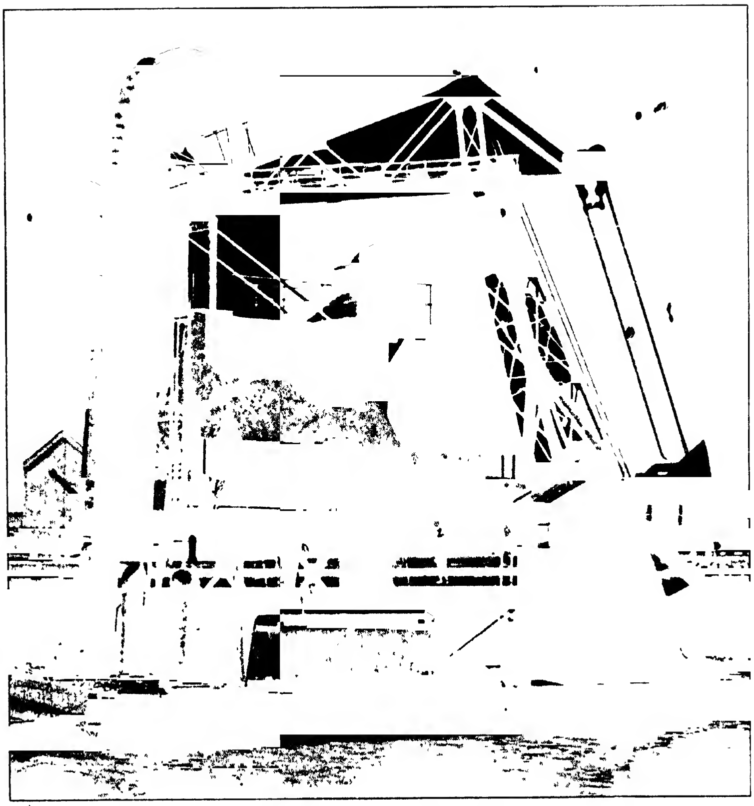


FIG 126 —ONE OF MITCHELL'S FLOATING CANTILEVER GRAIN ELEVATORS AT AVONMOUTH DOCK—IN HOUSED POSITION—BUILT BY MESSRS SPENCER & CO, LTD, MELKSHAM

proportions of the giraffe with the celerity of the mongoose, the poise and elegance of the gazelle, and with an appetite for grain that is appalling; all done by balancing. It is a fact that none of the older floating unloading devices have the flexibility of the latest type, though they have done and are still doing excellent work.

We will confine our attention to a brief description of the Mitchell Elevator, as the brief we hold is for the adoption of the best and most labour-saving appliances more than for their historical development.

The photographic view, Fig. 125, illustrates one of two floating elevators built upon this system to the order of Messrs. C. J. King & Sons, Bristol, for use in the Avonmouth Dock, by Messrs. Spencer & Co., Ltd., Melksham, Wilts. The normal capacity of these elevators is 100 tons per hour, and the maximum reached is 120 tons.

The telescopic elevator leg has a total length when extended of 44 ft., and 27 ft. when closed. The endless chain carrying the buckets is so arranged that when the leg is lowered, as much chain is let out in front as is taken up at the back, so that it remains at a constant length and even tension.

Each elevator is driven by a direct-coupled electric motor of 16 b.h.p. at the head of the elevator, thus doing away with all driving chains. It is carried on the end of a cantilever jib of 30 ft. centres, which in turn is carried on the top of a cantilever post 26 ft. 6 in., centres, the post

rotating on trunnions carried on the top of the turntable 16 ft. 6 in. above the deck.

The top of the jib is provided with a conveyer band which carries the grain from the elevator to a shoot running down the post, which in turn discharges into swivelling shoots through the deck into the well of a second, but stationary, elevator. These swivelling shoots are so arranged that they automatically adjust themselves for every movement of the elevator leg. The band is of canvas and rubber, and is provided with diagonal ribs to facilitate the grain running uphill when the jib is dipping downward more than 20°. The ribs are placed diagonally so that they will run over the return idlers without shock.

The grain is re-elevated by the deck elevator (also to be seen in the illustration) to any required height, and dropped into a hopper from which it is weighed and delivered.

Weighing is accomplished by six "Avery" automatic scales, three on each side, which deliver either into sacks, or shoot loose at will. The elevators are also provided with a means of delivering grain loose, and unweighed into barges on either side, and also with a portable conveyer for delivery ashore to bands on the quay when necessary.

The range of motion is very extensive, the elevator being able to work from a point 20 ft. 3 in. below the waterline, and it can also be lifted clear over the side of a steamer having 40 ft. freeboard.

The electrical energy is generated on board by a high speed engine and suction gas plant.

When required for towing, the elevator can be turned right round and stowed over the top of the weigh-house in a position of absolute safety, see Fig. 126.

The barge upon which the elevator is built is 65 ft. long by 26 ft. 6 in. overall, and has a depth of about 10 ft. 6 in.

COALING LOCOMOTIVE ENGINES.

As far as this country is concerned, the mechanical coaling of railway engines has only been adopted within comparatively recent years. Beyond one or two earlier and minor attempts by other lines, the London & North-Western Railway has led the way in adopting really serviceable installations, and it is to be hoped that this lead, and the experience gained by it, may make the mechanical coaling of railway engines play an indispensable part in the economy of our railway systems. The reasons for our lagging behind in this respect are rather complex: they were given by Mr. C. J. B. Cooke, M.I.C.E., in his paper on the Locomotive Coaling Installation at Crewe, but want of space does not permit us to go fully into them here. Probably the chief reasons are, the congested state of locomotive yards and the comparatively close proximity of collieries to the coaling centres, and perhaps also the fact that coaling by hand labour can be done cheaply in peace time, so that a large capital outlay for handling comparatively small quantities is not justified, as it burdens the actual cost of coaling too much, so that then the monetary advantage between mechanical and hand coaling is not very marked.

We must here realise that the coaling operation of railway engines is generally intermittent in more than one sense, so that a comparatively small staff can coal the engines from barrows or skips, filled previously and between the calls of the engines at the stage for coal, conditions which do not obtain in other coaling plants.

In America where mechanical coaling has been developed to a fine art, it must be admitted that the labour problems in one way or another have been responsible for this advance. In this country labour has hitherto been plentiful and inexpensive, and thus it has been practically admitted before the war that the raised oldfashioned coal-stage with its hand-

shovelling from wagon to a barrow or skip which can be tipped into the tender by a simple crane was the best method as regards convenience, small first cost, and equally small upkeep. But the war has changed all this, and if it was over to-morrow the labour conditions would not be improved for years to come, so that we are more or less in the same predicament in which the United States railways are, and a capital outlay in due proportion to the capacity of the coaling plant will be justified and economical for years and most probably for good.

The international methods adopted for the coaling of railway engines are various The one which appeals to the writer most is that used in the United States, where railway trucks are taken up a gently inclined track by a locomotive and the contents dumped into bunkers at a level sufficiently high to coal the engines by gravity. This would be an intermittent method and probably one of the earliest. Another intermittent system is the locomotive crane and grab, which has the advantage that the ashes can at the same time be removed by the same plant.

The next development is one on a continuous system of handling. Here a bucket elevator lifts the coal out of a pit (into which it has been dumped by a self-emptying truck or by a coal tip) to a series of overhead bunkers reaching either across the lines of rails upon which the engines are to be coaled, or alongside and between two tracks or two pairs of tracks, into which the coal is deposited by one of the various types of conveyers More frequently the gravity bucket conveyer has taken the place of the before-mentioned elevator and conveyer, or an inclined conveyer, like that employed in the installation at Crewe, takes the coal from a track hopper to the bunker or bunkers.

One of the latest developments is an inclined conveyer of a special type (to be further described later), which takes the coal direct into the tender of the engine without the intervention of bunkers, in which case the store of coal is contained in waiting trucks. This latter plan is probably one of the best, as it occupies but little room. In the United States, where what is called "run of mine" or lump coal is practically universally used, the continuous system, which of necessity cannot handle very large lumps without making the elevator and conveyer of unreasonable dimensions for the ton-hour capacity of the plant, has been abandoned again for an intermittent system Ordinary bucket elevators have been used at an intermediate period with buckets 24 in. to 36 in. long by 20 in. to 24 in. wide, but even these have proved inadequate for very large coal.

The choice of the installation for a specific proposition depends naturally upon the available space and the duty required. A crane and grab would probably be applicable for the smaller capacity, while the other systems are more or less applicable for any capacity, from the smallest to the largest. The inclined ramp first described, and the plant with an inclined conveyer, require a narrow and long area, while the other methods could be accommodated on a square or oblong piece of ground. In congested yards only the vertical bucket elevator and the gravity and balanced bucket are permissible, as occupying the smallest site

We will now go a little more fully into the systems already outlined. There are many more, but we are only dealing with the principal ones.

A locomotive crane and grab are used more particularly in America for coaling railway engines. In the simplest form the coal is grabbed direct out of the railway truck, swung round to the engine standing on an adjacent track, and lowered gently into the tender. Frequently there is a pit between the lines where the engines are coaled, into which the ashes are dropped during the coaling operation, and the same grab can remove the ashes afterwards into empty trucks. Sometimes self-unload-

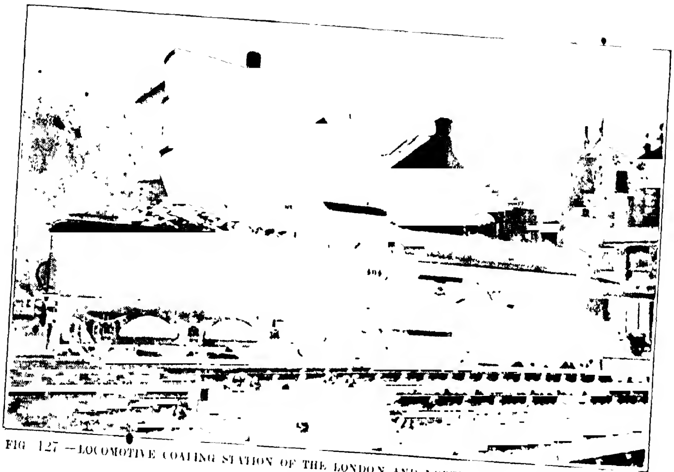


FIG 127.—LOCOMOTIVE COALING STATION OF THE LONDON AND NORTH WESTERN RAILWAY CO AT CAMDEN TOWN

ing trucks are used for bringing the coal, when it can be dropped into a similar pit to that for the ashes, in which case the coal truck need not stand by but can leave the coal and be run away again, whilst the same crane and grab transfers the coal as and when required from the pit to the engines.

The Brown Hoisting Machinery Co. build such installations with a lifting capacity of from 10 to 14 tons at a radius of 15 ft, making 50 trips per hour and operating a grab with a capacity of 54 cub. ft., taking from 2,000 to 3,000 lbs of coal with each trip.

Two men are necessary, one on the crane and one to assist the engine driver.

The principal advantage of such a plant is, that it constitutes a portable coaling station within certain limits, as the locomotive crane can haul the coal trucks where wanted. In case of a breakdown the crane can also be used by the breakdown gang for clearing the line, after the grab has been replaced by the necessary tackle. But there are disadvantages, the cost of coaling per ton is a good deal higher than with the other types, and the damage to which the trucks are exposed by the grab is decidedly detrimental

FIG. 128.—LOCOMOTIVE COALING STATION OF THE LONDON AND NORTH WESTERN RAILWAY CO AT CAMDEN TOWN

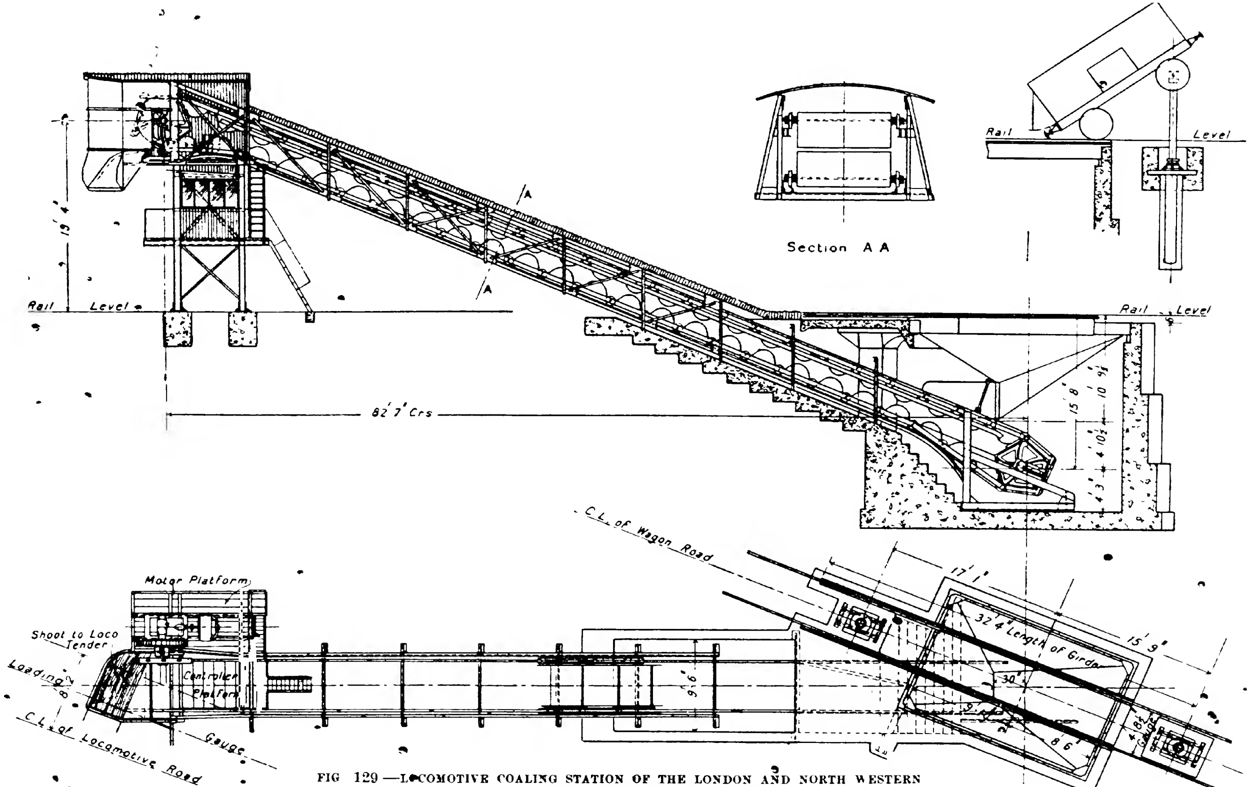


FIG 129 —LOCOMOTIVE COALING STATION OF THE LONDON AND NORTH WESTERN RAILWAY CO. AT CAMDEN TOWN

Locomotive Coaling Stations of the L. & N.W. Railway.

The automatic locomotive coaling plant started to work in 1913 at Crewe is, as has been mentioned, the first of any magnitude erected in this country. It was described in the Proceedings of the Institution of Civil Engineers by Mr. C. J. Bowen Cooke, who is responsible for the design. The main features are a wagon tippler which dumps the coal into a track hopper and via a coal-breaker and inclined tipping tray conveyer, and delivers it into one of two bunkers for two classes of coal, Welsh and "hard" coal. From these silos the coal is delivered, after passing calibrating chambers, to the tenders. The inclined conveyer is capable of handling 60 tons per hour. The bunkers hold 300 tons (100 tons of Welsh and 200 tons of "hard"), which is sufficient to coal all engines during the night without the conveyer working. The average daily (24 hours) quantity doled out to 140 to 150 engines is about 450 tons. A staff of three men by day and one by night are necessary, and the conveyer runs 10 hours per day. This installation was erected by Babcock & Wilcox.

The locomotive coaling plant at Camden Town, likewise of the L. & N.W. Railway, and equipped by Fraser & Chalmers, Ltd., is on similar lines, but minus the bunkers or silos. It was thus necessary to make the conveyer of such a capacity that the contents of 20 to 25 buckets were sufficient to charge a tender, so that the conveyer must be running just for that short space of time necessary for these few buckets to discharge. *The coaling at this spot was previously done by hand, and the sheds provided for the purpose accommodated eight to ten locomotives simultaneously. Normally over a hundred engines are coaled here daily, while during holiday seasons this number has been greatly exceeded, the staff required being, therefore, considerable. With the new arrangement the very largest engine can be coaled in less than three minutes, and not more than two men are required to operate it.

The plant, as shown in the accompanying Figs. 127 to 130, consists of an underground or track hopper holding about 15 tons, over which runs a standard rail-track, an inclined bucket elevator and a tower containing the driving gear, a control platform, and a coal shoot projecting over the turn-table siding, see Figs. 127 and 129. The coal wagons are brought one at a time over the underground hopper, and if they are of the bottom-door type their contents may be discharged into the hopper in the usual way. If they are of the end-door type, they are tipped by hydraulic rams, as illustrated in Fig. 128.

The coal is passed from the hopper down a shoot into the buckets of the conveyer. The buckets have each a capacity of one-third of a ton, and as they pass the hopper shoot at the rate of about eight a minute, the plant is capable of dealing with about 160 tons an hour, or, say, 2½ tons a minute. As the capacity of the buckets is known, the quantity of coal delivered to any engine can be measured approximately by counting the number of buckets discharged. The construction of the buckets is illustrated in Figs. 129 and 130.

At the tower the buckets discharge their contents direct into a shoot, which leads the coal down into the tender. The driving gear consists of a 15-h.p. electric motor transmitting through spur wheels. At Camden Town two men are employed on the plant. One attends to the moving and discharging of the coal wagons, while the other controls the starting and stopping of the conveyer and the coaling of the engines generally.

Compared with the coaling sheds previously employed, the plant takes up very little room, so that it results in a saving of space, wages and time. The charge for power used is very small indeed. The engineers inform us that the time now spent in coaling is less than the time taken to shunt

*From "The Engineer" of April 2, 1915, by kind permission.

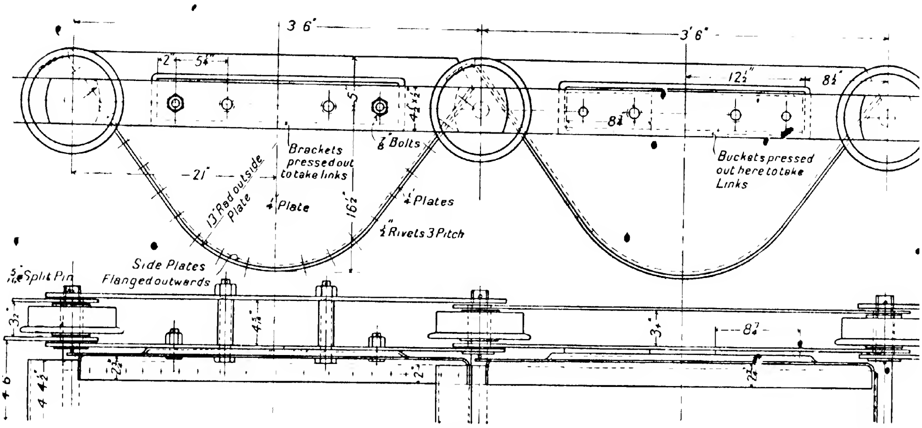


FIG 130—DETAILS OF CONVEYER OF THE LOCOMOTIVE COALING STATION AT CAMDEN TOWN

SWAIN

an engine on to the turntable, turn it, and move it away, and that the engine can be completely coaled, without loss of time, while it is waiting its turn at the table. In other words, the engines can be coaled and turned in no more time than it takes simply to turn them.

The latest achievement of the L. & N.W. Railway Company is the coaling plant at Edge Hill, Liverpool This, again, widely differs from the two earlier installations, and the principal feature is the solution of the difficulty of filling the bunkers without resorting to conveyers or elevators The loaded wagons are brought by an overhead circular line and are transferred to a spur with double lines, one for the full and the other for the empty coal trucks, which lines terminate above the bunkers and the trucks are unloaded in the well-known manner. It will be seen, therefore, that practically no mechanical equipment is necessary. About 150 locomotives are regularly stationed at Edge Hill, including all types of passenger, goods and mineral engines, both tender and tank type.

Previous to this new installation, the old hand coaling method was also here in vogue, and for an average day's loading of about 300 tons a staff of 16 men, working in three shifts, was required, and it took from 25 to 40 minutes to coal an engine. With the new plant the staff consists of 6 men working on two 12-hour shifts, and it takes only 3½ to 4 minutes to coal the largest type of express engine with about 7 tons of coal.

Locomotive Coaling Station of the N.E. Railway Company.

The N.E Railway Company is the first which followed the foregoing three examples by the N.W Railway Company. It is erected at the locomotive sheds at Dairycoates, Hull The installation is electrically driven and has been provided and erected by Spencer & Co., Ltd, of Melksham, to the design of the Railway Company's chief mechanical engineer, Mr. Vincent L. Raven.*

The underlying principle of this coaling plant is similar to that of the installation at Crewe The whole of the machinery is electrically driven, the current being supplied from either of two dynamos erected in the engine shed machine-shop, and driven by the shop engine. The sidings, together with the connecting road on which the coal arrives, are on a falling gradient of 1 in 95 to allow the loaded wagon to be lowered by gravity to the hopper for discharging and then run into the empty siding The underground hopper has in this case a capacity of

* This installation has been fully described and illustrated in "The Engineer" of October 14th, 1916, from which this extract has been taken.

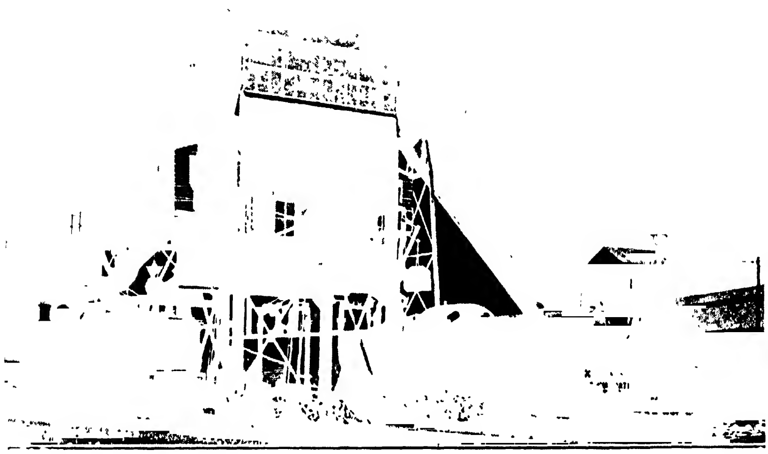


FIG. 131.—GENERAL VIEW OF THE LOCOMOTIVE COALING STATION OF THE NORTH-EASTERN RAILWAY CO. AT DAIRYCOATES, HULL.

20 tons, and the coal from this hopper falls on to a jigging screen, which permits the small coal to fall direct into the elevator, while the large passes through a crusher, which reduces the lumps to such a size as will easily pass through the locomotive fire doors, and then deliver it on to the elevator. The flow of coal from the hopper to the jigging screen is regulated by a gate operated from the ground level. The crusher and jigging screen are driven through suitable gearing by a 25 b.h.p. motor fitted on a platform in the hopper pit The bunkers are also here, the same as at Crewe, divided into two compartments of 100 and 200 tons capacity respectively, for the two different classes of coal used. Four delivery shoots are provided, two at each side of the bunkers for coaling the locomotives, thus allowing four to be coaled at the same time if desired. The delivery shoots are of the measuring type, holding 10 cwt. with each delivery.

An additional commodity, not provided at Crewe, are two 15 cwt. electrically driven coaling cranes, for coaling the locomotives when the elevator is out of use. They are so arranged as to lift the coal in tubs from the ground level on to the locomotive, and can be slewed through an angle of about 150 degrees. Under normal conditions the average number of locomotives coaled at this station is 135 per day, and these require approximately 275 tons of coal, and as the elevator is designed for a capacity of 50 tons per hour, it is only necessary to run the plant during the daytime

Fig. 131 gives a general view of the station.

AMERICAN PRACTICE.

To avoid the frequent breakdowns contingent on handling large coal in

bucket elevators, the Roberts & Schaefer Company, of Chicago, developed the Holmen, or balanced bucket, coaling station, in which system the coal is handled in buckets containing from one ton to two and one-half tons. These buckets are sometimes operated in pairs, one bucket counterbalancing the opposite bucket, or a single bucket is used with a counterbalance weight. The latter is the device more generally used at the present time.

The coal is dumped as usual into a receiving hopper below the track level. Between this track hopper and the elevator shaft is installed an automatic feeding device containing a

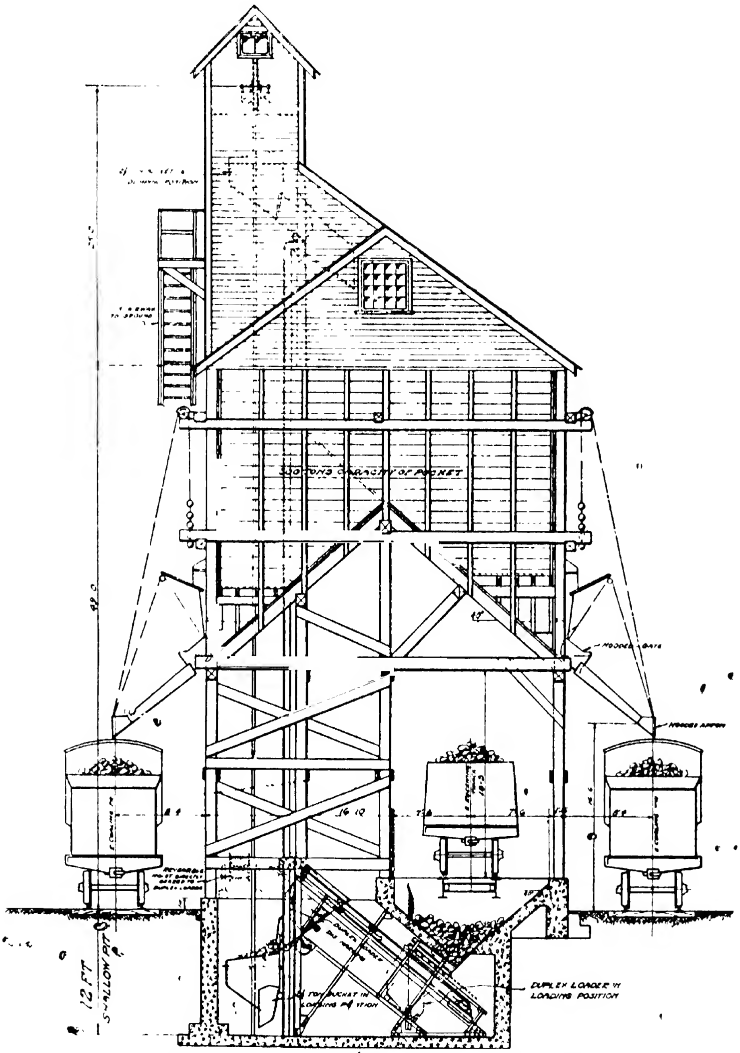


FIG 132.—AMERICAN LOCOMOTIVE COALING STATION OF THE ROBERTS & SCHAEFFR COMPANY, CHICAGO, ILLINOIS, U S A

charge of the same quantity of coal as is held by the large buckets without overfilling. The bucket which usually operates in a vertical shaft engages the automatic feeder, which in turn discharges its load into the bucket. The arrangement of the loader is such that the communication with the track hopper is cut off when the loader is being discharged into the bucket. The bucket is not of the usual tilting skip type, but has a large hinged door on the front. This door is held closed by rollers running on guides at the front of the shaft. When the bucket has reached the top of the coal bunkers, the rollers follow a bend in the guides, which allows the door (formed in the shape of a shoot) to open, see Fig. 132, and discharge the load of coal into the bunkers.

The first plants of this type required the constant attention of an operator to reverse the machinery, whether operated by an electric motor, steam, or gasoline power. In the subsequent development of the art it was found expedient that the plants should be operated automatically, leaving the operator free to dump coal or to take care of the oiling of the machinery. This led to the introduction of an automatic reversing skip hoist controller for operating the motor. To start the machinery it is only necessary to push a button, which energises a magnet on the controller. A plunger in the magnet or solenoid has one end carried into a dash-pot, therefore when the magnet is first energised it requires several seconds for the plunger to operate and complete the electric circuit to the motor. This period of time may be regulated from five to fifteen seconds, giving ample time either for the bucket to receive its load or to discharge it at the respective termini. At the top of the elevator shaft is located a slow-down switch, a stopping switch, and a starting switch. The travel of the bucket is at the rate of about 140 ft. per minute. When it strikes the slow-down switch, resistance is thrown into circuit, cutting the speed to about one-half, the bucket then proceeds to the stopping switch, and engages the stopping switch and starting switch at the same moment. The stopping switch arrests the motor, while the starting switch only energises the magnet coil on the controller in the reverse operation. This leaves the bucket at the top several seconds to discharge its load before the circuit is completed to the motor to cause it to reverse. The machinery, therefore, continues to operate in the forward and reverse motion until the current is cut off from the main line.

Where gasoline or steam power only is available, the automatic reversing hoist is driven by belt from the gasoline or steam engine through a series of cams and clutches, so that the engine runs continuously in one direction, while the hoist reverses automatically at either terminus, leaving a period of time sufficient for the discharge or receipt of the coal.

Such appliances have been installed in numerous plants, and are working perfectly, one of which is illustrated in Fig. 132. For taking the coal from the bunkers to locomotives, the undercut gate feeder has been found to be the best method, as there is no blocking of the gate opening when large lumps are present in the coal pocket.

The Roberts & Schaefer Company have recently developed, in addition to the ordinary undercut gate and apron used for delivering the coal to locomotives, a measuring device which measures a fixed quantity of coal to every locomotive, and provides a check on the record of coal taken, see Fig. 133.*

The device is of heavy steel plate construction, and has a capacity of 40 cubic feet, equivalent to one ton. As the driven shaft revolves, the mechanism opens the upper or inlet gate, and closes it against the flow of coal when the hopper is filled. As the shaft continues to revolve the lower gate is opened, allowing the coal to flow down the spout into the tender. This gate is then closed

* From the "Engineer," August 25th, 1916.

and the inlet gate again opened. The shaft makes four revolutions per minute, and delivers the coal at the rate of four tons per minute. It can be started or stopped as desired, but not with either gate partly open, so that the hopper is always either full or empty. This mechanism is driven by an electric motor of $\frac{3}{4}$ h.p. When coaling the fireman simply lowers the hinged spout by means of an endless chain and gear, and then pushes a lever or button to start the motor. A counter is so placed that its figures can easily be seen from the engine. Before taking coal the fireman notes on his coal ticket the number of his engine and the number shown by the counter, say 500, for instance After taking coal he enters the number then shown by the counter, say 505. This indicates that he has taken 5 tons. If the next man's ticket shows 505 and 512, it will indicate that he has taken 7 tons. As each ticket must show the number left on the counter by the preceding engine, the series must be consecutive, so that any attempt to show less than the amount taken will be apparent.

Fig. 133 shows the apparatus with the spout raised and the inlet gate A open. When the motor is started, the cam B will revolve and engage the roller on the arm C, shifting this arm to the left and closing the gate A, as in Fig. 133. Further revolution of the mechanism opens the discharge gate D by the arm E, and then closes it. When the end of the cam segment releases the arm C the inlet gate is again opened to admit a charge of one ton of coal.

In the United States similar locomotive coaling stations are in use in which the balanced bucket holds as much as 15 tons at a charge.

Fig. 134 shows a coaling installation of very graceful design erected by the T. W. Snow Construction Co., of Chicago, Illinois, U.S.A.

From the figures given in the Proceedings of the International Fuel Association, the total cost of handling one ton of coal by a gravity bucket conveyer appears somewhat less than for the same performance by other conveyers. In a plant handling 150 tons per 24 hours, the total cost is placed at less than two cents (1d.) per ton. There is a great similarity in the h.p. consumed by the different types of coaling plant which is astounding, at least as far as the continuous elevators and conveyers are concerned, including, however, the intermittent balanced bucket type, all working out at about 1d. per ton.

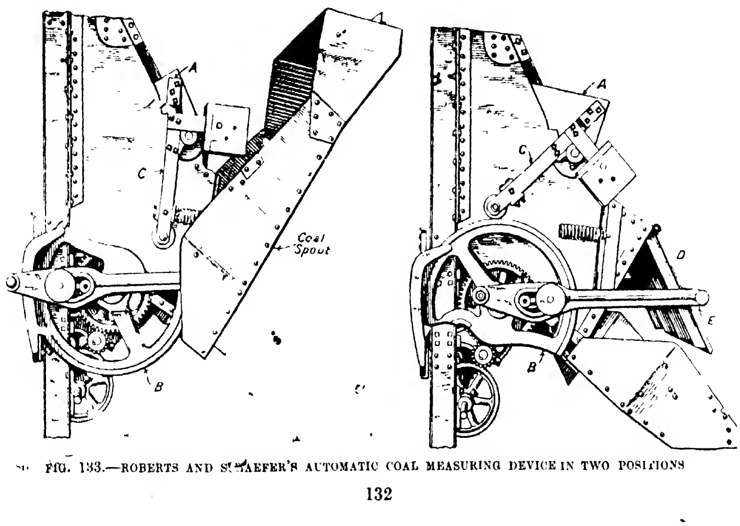


FIG. 133.—ROBERTS AND SCHAEFER'S AUTOMATIC COAL MEASURING DEVICE IN TWO POSITIONS

The handling by locomotive grab and crane is more expensive. However, the cost must vary with the capacity of the plant, and the larger the plant the greater the necessity for the mechanical equipment.

CONCLUDING REMARKS.

The foregoing pages contain the most important of the known and approved devices for saving, or aiding, labour in handling material. There are many other machines and systems which the author feels might have been included with advantage, but which he is reluctantly compelled to omit. Some of the subjects thus crowded out are the mechanical weigh-

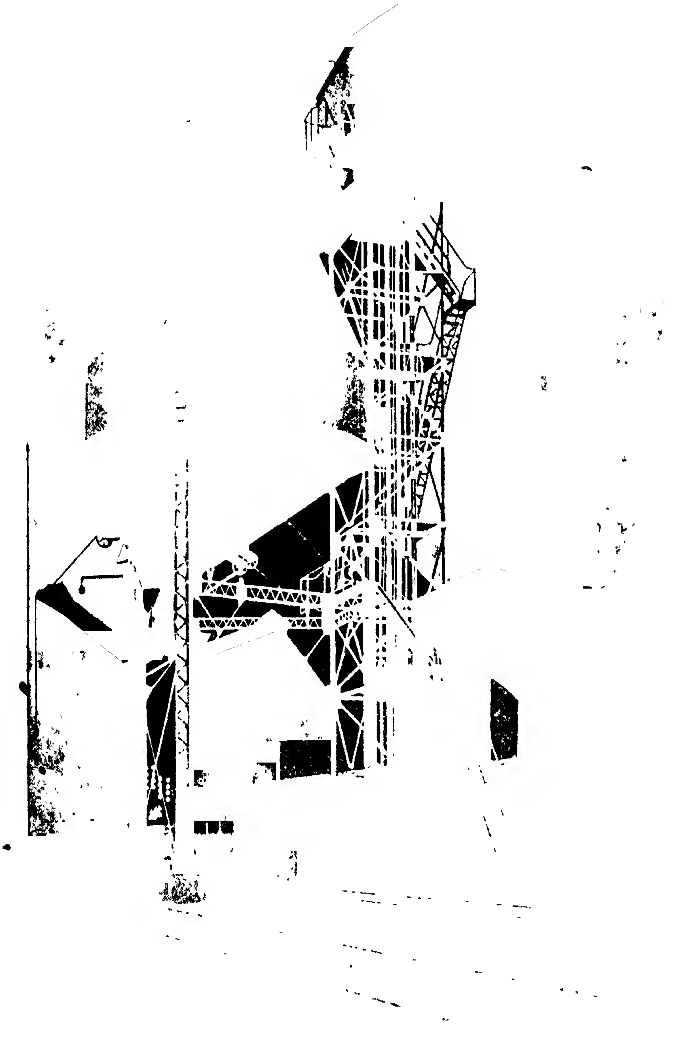


FIG. 134—COALING STATION OF THE T.W. SNOW CONSTRUCTION CO. CHICAGO, ILLINOIS, [illegible]

ing and registering of material; cranes and grabs; and especially lifting magnets for all kinds of iron work, scrap as well as plates and girders, in addition to the use of the lifting magnet in the blast furnace industry, where it is used to raise the pigs from the pig-bed, one of the most onerous tasks for man, which the machine can do to the greatest advantage. Then there are all the other mechanical operations in connection with blast furnaces, such as stocking the raw material, and after weighing conveying it to the top of the furnace, and last, but not least, the casting machines should be mentioned, which do away with the pig-bed altogether when their installation is possible. Regiments of men could be formed from the men who might be relieved in collieries, by the use of machines for mining the coal, not only for the actual coal-getting, but also for conveying it from the coal face to the roads. It is true that such machines are not either possible or economical in very narrow seams, but there are many collieries exploiting wide seams who are still employing the old methods, either in obedience to the men, or for want of enterprise, and this present crisis should be an opportune moment to install such plant.

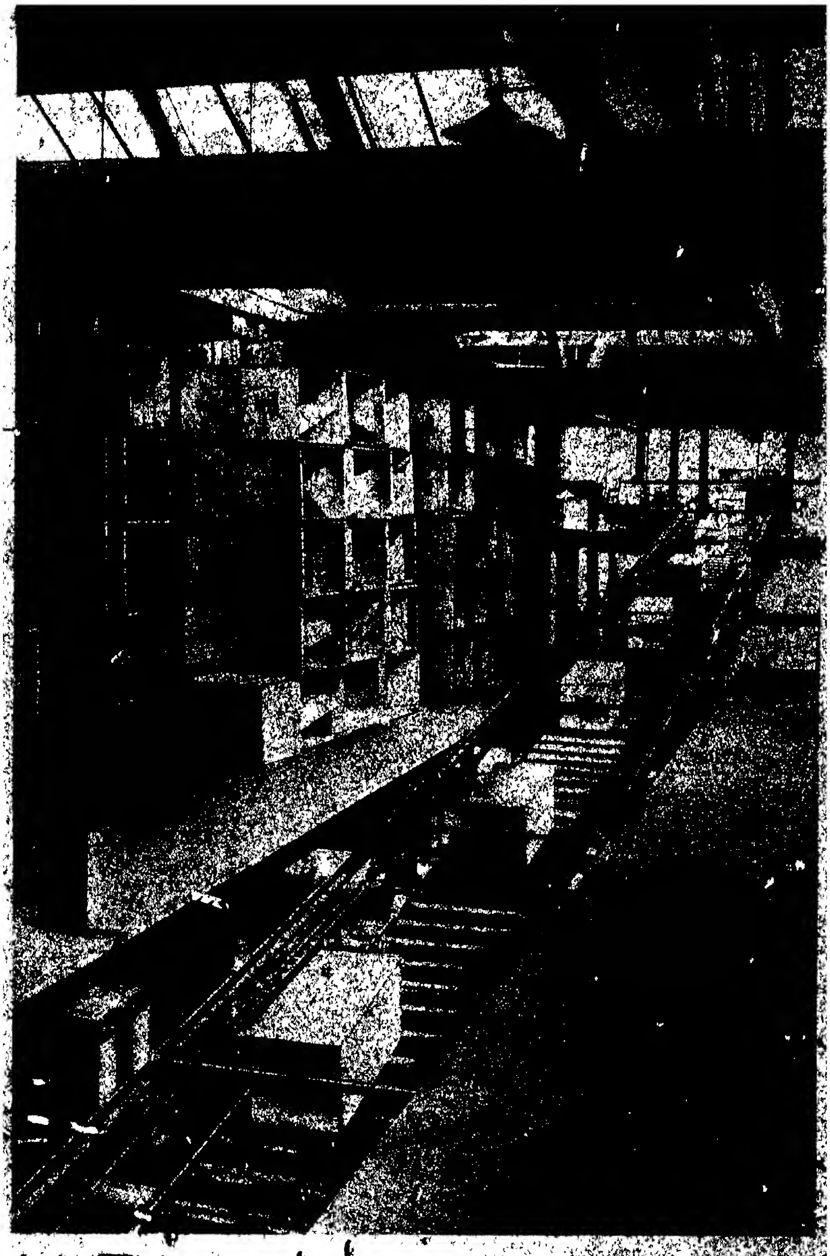
The principal and most obvious advantage of such enterprise is an expansion of the mining industry with the same labour roll, or a reduction of hands for the same output. The average tonnage per man per day for handwork is about 2 to 2½ tons, including all the men employed in and about the mine. With mechanical cutters and coal face conveyers the average tonnage per man per day is about 3 to 3½.

Then there are hosts of other opportunities for saving labour by employing the machine to expel ashes from ships, to handle coke from coke ovens, and endless loading and unloading devices. There is hardly an industry where labour-saving appliances could not be used with the greatest advantage.

The importance of handling all possible materials by machinery will not by any means cease after the war; it will then be as essential as now, because the world's markets—the Belgian, French and Russian, and, above all, the German—will be disorganised to such a degree that they cannot enter into serious competition for years, especially if we are prepared with labour-saving machinery. And we must here take into account that the world's demands have increased by the war rather than diminished; thus an enormous amount of new business, now hung up, is shortly to be shared presumably by the United States and Great Britain. If we pick out as an example only iron and steel, the above will be apparent. The world's total export of these commodities was 20,000,000 tons per annum before the war, of which Europe supplied 10,000,000, and of this Germany, as the second largest producer and chief exporter, supplied 6,000,000 tons. Now, if the war was over to-day, the credit and bounty system under which Germany has fostered her export trade must remain crippled for years.

The country which can cheapen the process of production most stands the best chance of winning the markets, and the mechanical handling of material is one of the chiefest aids to cheap production, a fact fully realised in the United States, and if we do not fall into line now, we shall know it later to our cost.

The King said: "We are fighting for a worthy purpose, and we shall not lay down our arms until that purpose has been achieved." Well, this purpose demands not only the direct personal sacrifice of many, but also national and industrial sacrifices. In addition to the adequate equipment and maintenance of our fighting forces, our industries should produce more actively than ever to satisfy the immense demands of a manufacturing and exporting nation, to continue its usual occupations in order to produce the wherewithal,



Installation for handling export cases of beer and stout, at Messrs. J. & R. Tennent Ltd.'s Wellpark Brewery, Glasgow.
Erected by THE HEPBURN CONVEYOR CO., LTD., Wakefield.

which is after all the sinews of a prolonged war. It is not mere platitude to argue that the man in the factory is as necessary to success in the war as the man in the trenches, the more so as peaceful industries have changed into factories for the production of munitions and equipments, and new factories have sprung up like mushrooms, all of which are impotent without an adequate staff of workers to enable them to pour out death-dealing weapons day and night This unfortunately must be so, but it is of national importance to do all industrial work, war or civil, with as few hands as possible, and to harness the labour-saving or labour-aiding machine into service, to do that kind of work where no brain is necessary.